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BODY SIZE WITH RELATION TO POPULATION DENSITY IN MAMMALS

BY VICTOR B. SCHEFFER

The first purpose of this paper is to present certain evidence of a decrease in body size in the Alaska fur seal (*Callorhinus ursinus*) with relation to a measured increase in population size; second, to review briefly the relationship reported to exist between body size and abundance in the brown rat, house-mouse, vole, muskrat, gray squirrel, raccoon, deer, and man. The body size: abundance relationship in mammals has not, we believe, received the attention it deserves. A third purpose of the paper, then, is to stimulate inquiry into the mechanics of body size regulation by density dependent factors in the environment.

With the exception of an albino form of house-mouse, the mammals referred to above are wild species of economic importance. The present advantage of using such animals for study will disappear as more is learned about methods of suppressing natural fluctuations in their numbers. Thus, as the wildlife manager becomes progressively more skillful in controlling irruptions of deer and muskrat, the less opportunity will he have of studying the influence of population pressure, and the more will he turn to captive animals for evidence.

The necessary conditions for a study of the size: abundance relationship are that both the subject population and the body size of its members shall be responsive to measurement from time to time. In measuring the population, the observer shall make certain that he is dealing continuously with the same genetic group; not now with one and later with another that has invaded the study area. And in measuring body size he shall be able to identify sex and age as a prerequisite to selecting comparable individuals. For example, references in the literature to "decrease in average body size" may refer only to a decrease in proportion of older and larger members of the population, not to a decrease in size of animals of the same age. Thus, intensive hunting of deer usually brings about a degradation in average size, which does not necessarily mean that the three-year buck is smaller than his counterpart measured before the start of intensive hunting.

The growth data for each of the mammals discussed here, with the exception of the fur seal and man, are presented with the warning that they apply to individuals of uncertain age. For the vole, which attains adulthood in three or four

months and may cease to grow, the selection of "adult" specimens is perhaps assurance enough that individuals of comparable age have been measured. For another mouse, however, Dice (1952) warns that "two-year animals average slightly larger than 1-year old in all body and skeletal measurements except hind-foot length." For larger mammals like the muskrat and raccoon it is certain that fluctuations in the age composition of the population do influence the final estimate of body size. Future studies should be based upon animals of positively known age, either marked individuals or species that exhibit yearly growth marks (annuli) of one kind or another.

We are concerned here with changes in body size provoked by fluctuations in population pressure. We are not concerned with changes provoked by disease, predation, adverse weather, or lack of shelter and food, unless such modifications of the environment are themselves the result in whole or in part of population pressure. Many examples of effects independent of population pressure could be cited. Davis (1949) found that wild rats living on garbage in the city were significantly heavier than those living on farm debris in the country. A prolonged winter storm in the north Pacific Ocean prevented young fur seals from feeding, thereby bringing them to the point of emaciation or death (Scheffer, 1950*a*). Fire, flood, or an insect invasion may seriously damage the local food supply of a mammal and likewise bring about starvation.

On the other hand, a mammal may abuse its own environment and as a result suffer a decline both in size and in numbers. The history of the reindeer on St. Paul Island is a striking example of a population decline (Scheffer, 1951). Here a herd of over 2,000 animals, confined by natural barriers, collapsed to only eight in a period of 12 years.

Crowding in a population may (1) affect the energy intake, or (2) affect the energy output, or (3) lead to the actual death of the weaker members. In the first case it may reduce the individual's share of food, or, along with the increased parasitism, disease, and emotional tension that tend to accompany crowding, it may reduce his ability to utilize food. In the second case it may burn energy through increased fighting and sexual contact, and by forcing the individual to travel farther afield in search of his share of food. In the third case it may result in the discriminate removal of the weaker, and generally smaller, members of a given age class,—those unable to survive the hardships of a peak population.

The point we wish to emphasize is this: a change in mean size may take effect horizontally, among nearly all members of an age class, or vertically, in selected survivors of the class above a certain threshold size. Thus, as we hope to demonstrate, a peak population may bring an across-the-board *reduction* in size or an *increase*, depending upon the degree of intraspecific competition. There seems to be no certain way of identifying horizontal as against vertical change. For example, let us say that the biologist measures an adequate sample (S) of two-year-old male muskrats in August, 1956, and a similar sample S′ in August, 1960. He finds the members of S′ significantly longer in body. Has the ratio, food-supply/energy-output, increased among the rats at large in the study area or have the shorter rats been killed by the longer?

Two avenues of research leading to a solution of the problem appear to be open. The first is careful scrutiny of the size frequency distribution in sample S′. A normal distribution will suggest the presence of ordinary mortality factors working impartially (horizontally) on all members of the age class. A distribution skewed toward the right, or truncated on the left, will suggest the presence of selective mortality factors working vertically against the shorter members of the class. The second approach is comparison of the mean size of muskrats in S′ with the mean size of their age-classmates, now dead or departed. Thus, if the members of S′ prove to be significantly larger, the biologist may conclude that these members of the recent sample represent the survivors of intraspecific combat; and he may subsequently conclude that an increase in size from S to S′ has been a vertical change. Obviously, however, opportunity to measure the dead and departed members of an age class is rarely presented outside the confines of the laboratory. Hence this method of distinguishing horizontal from vertical change is of little use to the wildlife manager.

It is unimportant whether change in size reveals itself in one generation or in several. A shrew with a life expectancy of about a year can live, broadly speaking, in only one population density environment; a deer can live through ten or more periods of fluctuating population pressure. What *is* important is the relationship between mean body size and abundance at any particular level in the rise and fall of the population.

In summary, the incentive for the writing of the present paper has been curiosity toward the relationship between body size and abundance in seals and other mammals under circumstances where size is affected by abundance. How does population density influence the energy budget and selective mortality? For a given population level, what is the probability that an individual will attain the maximum size predisposed by his genetic makeup? At what stage in expansion of a population does the influence of the group express itself through measurable change in the individual?

We have shown that the term "average body size" may be applied, first, to the mean size of the individual regardless of age; second, to the mean size as a product of what may be called the imposed or adventitious environment; and, third, to the mean size as a product of the internal or sociological environment. With the third category only are we further concerned. For critical reading of the manuscript or advice on certain parts we are deeply indebted to Dennis Chitty, David E. Davis, Paul L. Errington, Paul Hickie, Karl W. Kenyon, Mrs. Nellie L. Landblom, Frederick E. Smith, and Ford Wilke.

THE ALASKA FUR SEAL (CALLORHINUS URSINUS)

DECREASE IN BODY SIZE

The size of the seal apparently decreased in the three decades between 1913–1920 and 1941–1952 while the population was rising to a plateau, increasing over fourfold in the process (Alaska Fishery and Fur Seal Industries; Kenyon, Scheffer, and Chapman, 1954). Tables 1 to 4 compare the average body size of the male seal in 1913–1920 and in 1941–1952. Decreases in length and weight are illustrated in Figure 1.

TABLE 1.—*Weight of male fur seals, ages 1 and 3 to 8 years, kilograms*[1]

Age	Period	N	Range	M	SD	V	D	S	Note
1	*1913–18*	*13*	*12.7–18.9*	*15.9*	*1.9*	*12.3*			
	1941	12	12.5–22.0	16.8	2.4	14.3			
3	*1915*	*102*	*20.0–39.2*	*29.5*	*4.1*	*13.9*			[2]
	1944	21	19.1–31.3	24.3	3.8	15.7			[3]
	1951	90	21.3–36.3	28.0	3.1	11.2	1.5	NS	[2, 4]
4	*1916*	*74*	*24.9–48.1*	*39.1*	*5.3*	*13.5*			[2]
	1944–45	24	23.1–51.3	33.4	6.6	19.7			[3]
	1951	26	27.2–48.1	35.5	5.2	14.6	3.6	*	
5	*1917*	*38*	*33.7–69.4*	*53.3*	*8.3*	*15.6*			
	1945–46	28	30.9–57.2	44.9	7.2	16.0	8.4	**	
6	*1918*	*34*	*80.8–144.2*	*80.5*	*20.8*	*25.8*			
	1946–47	22	46.3–83.5	60.7	10.3	17.0	19.8	**	
7	*1919*	*24*	*67.1–220.7*	*128.9*	*43.2*	*33.5*			
	1948	6	69.0–156.6	94.5	32.2	34.1			
8	*1920*	*13*	*110.2–159.2*	*126.1*	*14.7*	*11.7*			
	1949	4	80.8–222.5	175.5	65.3	37.2			

[1] Converted from pounds. Abbreviations: N, number of specimens; M, mean; SD, standard deviation based on N-1; V, coefficient of variability; D, difference between means in a comparison of data from the 1913–1920 period and the 1941–1952 period; S, significance of the difference between means. Where one sample is less than 13, or where the data are suspected of bias, the significance has not been calculated. (**) significant at the 1 per cent level, (*) significant at the 5 per cent level, (NS) not significant.

[2] In this and two other instances where the original sample was large,—N exceeding 73—the weights were lumped for convenience into classes of 3 pounds each. The resulting total number of classes is in no instance less than 12.

[3] Sample screened for commercial size by the killing crew.

[4] As against one sample of each age class for the early reference period (italics), there may be several for the recent period. In this example a recent sample was taken in 1944 and another in 1951.

Method of study.—In 1912, 5,228 seal pups were hot-iron branded on the islands of St Paul and St. George in the Pribilof Islands, Alaska (Scheffer, 1950*b*). From this marked group, animals of known age were subsequently killed and measured. The results were published (Alaska Fishery and Fur Seal Industries, 1913–1922; Osgood, Preble, and Parker, 1915) or were preserved in manuscript (Hanna, 1927). From two men who participated in the original study we understand that the specimen seals were selected on the basis of sex, but were otherwise sampled at random (talk with G. Dallas Hanna, 1941; letter from L. C. McMillin, February 25, 1945). The specimens were taken in commercial sealing operations similar to those of today, wherein only male animals two to five years old are intentionally killed. Our comparisons are thus confined to males.

With the creation of the Fish and Wildlife Service in 1940, a new investigation of the seal herd was launched. Five thousand seal pups were branded in that year and 10,000 were branded and metal-tagged in 1941. In each of the years 1947, 1948, and 1949, approximately 20,000 pups were tagged (Scheffer, 1950*b*; Kenyon, Scheffer, and Chapman, 1954). The survivors provided the series of body measurements taken in 1941–1952 as source materials for the present paper.

All specimens, then, are of comparable age and sex. All but yearlings were taken during the summer, from May 28 to August 22, mostly from mid-June to the end of July. (Yearlings are available on land only from August to November.) Body length was measured in a straight line from tip of nose to base of the diminutive tail—the "field length" as

TABLE 2.—*Field length of male fur seals, ages 2 to 7 years, millimeters*[1]

Age	Period	N	Range	M	SD	V	D	S	Note
2	*1914*	*13*	*921–1086*	*1029*	*47.3*	*4.6*			
	1943	138	857–1092	999	42.7	4.3			[2]
3	*1915*	*102*	*946–1315*	*1101*	*68.1*	*6.2*			
	1943	337	906–1176	1047	58.7	5.4			[2]
	1944	144	965–1168	1063	41.7	3.9			[3]
	1950	1240	940–1168	1064	35.4	3.3	37	**	
	1951	1260	940–1194	1069	39.2	3.7	32	**	
	1951	90	991–1168	1082	37.1	3.4	19	NS	[3]
	1952	816	991–1194	1084	29.5	2.7			[3]
4	*1916*	*74*	*1016–1346*	*1221*	*66.3*	*5.4*			
	1951	460	1016–1321	1141	50.8	4.5	80	**	
	1951	26	1067–1321	1165	55.1	4.7	56	**	[3]
	1952	354	1041–1245	1136	30.0	2.6			[3]
5	*1917*	*38*	*1245–1524*	*1406*	*65.5*	*4.7*			
	1945–46	26	1245–1397	1316	47.3	3.6	90	**	
6	*1918*	*34*	*1429–1772*	*1545*	*82.0*	*5.3*			
	1946–47	20	1270–1499	1382	68.7	5.0	163		
7	*1919*	*24*	*1492–1981*	*1758*	*125.7*	*7.1*			
	1948	6	1448–1778	1532	125.2	8.2			

[1] Converted from inches; snout to base of tail; see abbreviations in footnote to Table 1.
[2] Sample screened for commercial size by the killing crew.
[3] A subsample taken 21–23 July.

recorded for over a million fur seals killed commercially in the past forty years. Body weight was taken to the nearest pound or half pound upon seals bled with a knife through the heart; fur dry or damp, never soaking wet. Since bleeding is partly internal, the loss of weight rarely exceeds one-half pound. Condylobasal length, basilar length of Hensel, and zygomatic width were taken in millimeters by standard methods (Grinnell, Dixon, and Linsdale, 1937).

In the 1913–1920 period, data were derived from specimens born and recovered on both of the Pribilof Islands. In 1941–1952, data were obtained from seals born and recovered on St. Paul only. The difference in technique seems to be unimportant, for examinations of body length in 315 seals, and weight in 302, reveal no differences between the data from St. Paul and from St. George outside the limits of sampling error, and no differences consistently favoring one island.

For lack of data, both in the earlier reference period and in the recent, we are unable to present a complete array of measurements of body and skull in all ages from one to eight years.

As previously stated, the specimens of the 1913–1920 period were collected at random. During the recent period, however, several series of specimens were collected on the killing field *after* they had been chosen by the killing crew as animals of commercial value. These screened series are identified by footnote 3 in Tables 1 to 4 and are included only for the sake of completeness. A screened sample may, in fact, closely resemble an unscreened (random) sample from the same age class (Scheffer and Wilke, 1953), but cannot be relied upon to do so. Further to the point, a screened sample appears to vary about like an unscreened one. We illustrate with data from Tables 1 and 2:

For the weights of 111 three-year males the percentage variability among screened specimens was 15.7; among unscreened specimens it was 11.2.

For the weights of 50 four-year males the percentages were 19.7 and 14.6.

TABLE 3.—*Skull length of male fur seals, ages 2 and 4 to 8 years, millimeters*[1]

Age	Period	N	Range	M	SD	V	D	S	Note
			Condylobasal length						
2	*1914*	*11*	*170–181*	*175*	*3.3*	*1.9*			
	1943	10	166–176	172	3.6	2.1			[2]
			Basilar length of Hensel						
4	*1916*	*23*	*175–197*	*186*	*6.2*	*3.3*			
	1944–45	22	162–187	175	6.7	3.8			[2]
5	*1917*	*15*	*185–200*	*194*	*4.7*	*2.4*			
	1945–46	13	171–190	181	4.8	2.7	13	**	
6	*1918*	*14*	*189–210*	*203*	*5.9*	*2.9*			
	1947	19	181–201	191	5.5	2.9	12	**	
7	*1919*	*5*	*201–221*	*211*	*11.2*	*5.3*			
	1948	6	191–207	199	6.5	3.2			
8	*1920*	*6*	*212–232*	*219*	*12.5*	*5.7*			
	1949	3	198–214	208	9.0	4.3			

[1] See abbreviations in footnote to Table 1.
[2] Sample screened for commercial size by the killing crew.

TABLE 4.—*Skull width of male fur seals, ages 4 to 8 years, millimeters*[1]

Age	Period	N	Range	M	SD	V	D	S	Note
			Zygomatic width						
4	*1916*	*23*	*109–123*	*115*	*3.2*	*2.8*			
	1944–45	22	100–119	110	4.4	4.0			[2]
5	*1917*	*14*	*111–126*	*120*	*3.6*	*3.0*			
	1945–46	13	106–122	115	5.4	4.7	5	*	
6	*1918*	*13*	*119–130*	*125*	*4.3*	*3.4*			
	1947	20	111–132	121	4.6	3.8	4	NS	
7	*1919*	*4*	*130–145*	*139*	*6.4*	*4.6*			
	1948	6	120–141	127	7.8	6.1			
8	*1920*	*6*	*134–148*	*143*	*5.3*	*3.7*			
	1949	4	120–148	138	12.3	8.9			

[1] See abbreviations in footnote to Table 1.
[2] Sample screened for commercial size by the killing crew.

In the field lengths of 3887 three-year males the percentage variability among screened specimens was 3.5; unscreened, 3.5.

In the field lengths of 840 four-year males the percentages were 2.6 and 4.5.

The samples taken by L. J. Palmer in 1943 shortly before his death are not clearly described in his notes, but from a talk with several of his contemporaries we believe that the samples were screened, and to be conservative we have so recorded them.

The significance of the difference between means (Column 9 in Tables 1–4; Column 6 in Table 6) in the 1913–1920 and the 1941–1952 periods has been calculated only for those pairs of samples in which each member of the pair contains at least 13 specimens; and only for those pairs believed to have been sampled at random. Since the data are unusually

variable, logarithmic transformations rather than observed measurements have been used in estimating the significance of the difference between means.

We have chosen to express the significance of the difference between means for each individual comparison, and have not attempted to derive a figure for significance based on the comparisons *en bloc*. The reason lies in our uncertainty as to the extent to which the samples may overlap, or represent two sides of the same coin. As a case in point, consider the sample of 28 five-year males collected in 1945–1946. Here we know that, for all 28, the weights were obtained; for 26 the field lengths, for 13 the skull lengths, and for 13 the skull widths. Now the chances are very great that a seal with a heavy body will also have a long body and large skull. Hence, we would not be justified in considering as independent data the measurements of these four variates. On the other hand, consider the large sample of 1,260 three-year males measured for body length in 1951. Of these, the weights were obtained for only 90 and the skull dimensions for none. Here we would probably be justified in considering the length data and the weight data as though they came from separate reservoirs. In summary, we have chosen to present individual comparisons only, with the implication that their total significance is greater than that of any single one.

Results.—(Tables 1 to 5). Of fifteen comparisons based upon four age groups (three to six years) and four measurements (body weight, field length, skull length, and skull width), nine point to a significant decrease in mean body size at the 1 per cent level and three at the 5 per cent level. For three comparisons, the differences are not significant.

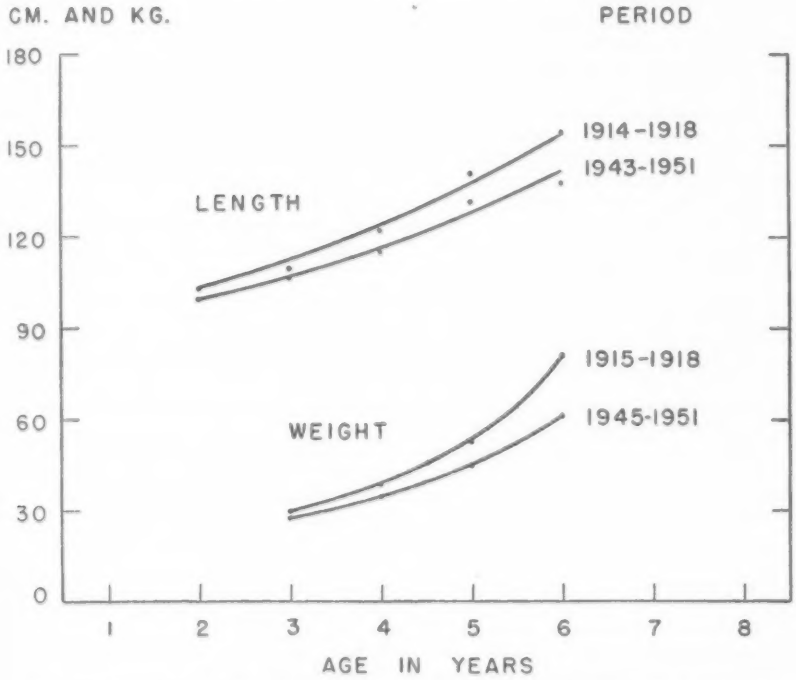

FIG. 1.—Growth rate curves for the male fur seal during an earlier period (low population) and during a recent period (high population). Selected data from Tables 1 and 2.

TABLE 5.—*Per cent decrease in size of male fur seals 1913–1920 to 1941–1952*[1]

Age	Per cent decrease in weight	Per cent decrease in field length	Per cent decrease in condylobasal length	Per cent decrease in basilar length	Per cent decrease in zygomatic width
2			1.7		
3	5.1	3.1[2]			
4	9.2	6.5[3]			
5	15.8	6.4		6.7	4.2
6	24.6	10.5		5.9	3.2

[1] Data from pairs of samples for which significance of difference between means was calculated; see Tables 1 to 4.

[2] Mean of 3 comparisons.

[3] Mean of 2 comparisons.

The decrease in size between seals of the reference period and those of the recent period is more conspicuous in animals approaching adulthood (Table 5). The inference may be drawn that whatever factors have limited the growth of the seal have been operative throughout the growing period and have had a cumulative effect in the adult. (We will note a similar phenomenon when we come to a discussion of stature changes in man.)

Variability in size in the two periods, early and recent, is difficult to compare. Certain patterns, distorted by sampling error, emerge from the data at hand (Tables 1 to 4). First, variability during both the reference period and the recent period shows a quite natural tendency to rise with age of seal. That is, with increase in age the spread between small and large individuals, or "runts" and "giants", has greater opportunity to widen. In body weight, especially, the rise in variability is pronounced. Scheffer and Wilke (1953) found that the male grows most rapidly while crossing the threshold of sociological maturity, ages seven and eight, when the "bachelor" turns into the "bull." In highly social *Callorhinus* this sociological coming-of-age lags about four years behind sexual maturity, ages three and four (Scheffer, 1950c).

Second, in the reference period 1913–1920, variability in weight rises sharply during the sixth year of life, while in the recent period it does not start to climb until the seventh. Has population pressure caused a delay of one year in the attainment of a secondary sex character, namely, the massive development of shoulder and neck of the breeding bull? (See also Fig. 1.)

Third, body length data for the adolescent ages three to six, of which we have the largest samples, fit into a rather consistent pattern. In the reference period, the three-year olds are evidently more variable than in the recent period, but with increasing age this distinction subsides. By age six, variability in the two periods is the same. There is no ready explanation of the trend, if indeed it is a trend.

Fourth, relying upon the field length data,—our richest measurements—we are inclined to feel that variability is less in the recent period than in the reference period. Dampening of variability and slackening of population growth may perhaps have mutual sources.

Fifth, variability in skull measurements can scarcely be interpreted from the few samples at hand. The trend in basilar length in the middle years corresponds roughly to the trend in body length, as might be expected.

Sampling error.—In Table 6 an attempt has been made to evaluate the importance of sampling error. For body length of three- and four-year males, five independent samples taken *within* the recent period are compared. In one comparison, the difference between means of samples taken in the same year prove to be significant at the 5 per cent level. In the remaining comparisons, the differences are not significant.

In view of the magnitude and consistent direction of the difference between means of body size in 1913–1920 and in 1941–1952, sampling error does not seem to invalidate the

main conclusion drawn from this study, namely, that the fur seal has decreased in size. Only two anomalies will be noted among the 33 pairs of samples in Tables 1 to 4, that is, body weights of eight-year-olds and yearlings collected in the recent period appear to be *greater* than their counterparts of 1913–1920. It will be seen, however, (Table 1) that the comparison of eight-year weights is based on only four specimens in the recent period, surely an inadequate sample.

The discrepancy in yearling weights can not as easily be explained. Of Hanna's thirteen "yearlings" ten were unbranded and were identified by means of dentition and skull size. It is very likely that the ten were indeed yearlings, although this can not be said with assurance. The yearlings are a peculiar group inasmuch as only a few of their numbers, certainly less than half, return to land. Are these representative of their class? Granted they are, it is reasonable to believe that there is little or no difference in body size between the very young seals of today and those of 1912–1920, for we have just noted the existence of a gradient—an increase in size discrepancy with age. This is another way of saying that we believe the genetic makeup of the seal has remained essentially unaltered throughout the recent period of population change; that the newborn seal today is as large (though perhaps not as fat) as his counterpart of 1913–1920.

Before leaving the subject of sampling error the reader should clearly understand that the data from 1913–1920 and from 1941–1952 were obtained by two separate groups of observers. Significant differences in the data have been found. These differences could result from (1) actual differences in body size, or (2) non-representative sampling, or (3) the measuring techniques employed by Hanna and his associates as against those employed by the present writer and his associates. From knowledge of field conditions we believe that the influence of variable technique can be ignored. The probability is remote that errors in the same direction were made year after year in obtaining body weight, body length, and skull length and width.

As to whether the samples were representative, there is room for doubt. Fur seals display a sort of class consciousness, and individuals of the same age and sex tend to draw together, both on land and sea. (There are important exceptions.) Does this social trait extend also to seals of similar size *within* the age class? Quite obviously seals are extremely variable in body size. If also they show a slight tendency to distribute themselves in non-random size groups, the reader will appreciate the difficulty of obtaining a reliable sample for study of body size. The data in Tables 1 to 4 should be studied with this reservation in mind.

Corollary evidence.—There is strong supporting evidence that the male seal *has* decreased in size. The age composition or age spectrum of the commercial kill in recent years, estimated through use of Hanna's length-standards, does not resemble the composition indicated by another and better source of evidence, namely, tooth-ridge counts made upon

TABLE 6.—*Field length of male fur seals, ages 3 and 4 years, millimeters; significance of the difference between means of samples taken wholly within the recent period 1950–1951*[1]

Age	Year	N	M	D	S
3	1950	1240	1064		
	1951	1260	1069	5	NS
3	1950	1240	1064		
	1951[2]	90	1082	18	NS
3	1951	1260	1069		
	1951[2]	90	1082	13	NS
4	1951	460	1141		
	1951[2]	26	1165	24	*

[1] See abbreviations in footnote to Table 1.

[2] A subsample taken 21–23 July.

animals in the kill. Counts of annular ridges are highly accurate for three- and four-year males (Scheffer, 1950*d*). The following comparison of the estimated age-composition of the kill in former and in recent years is illuminating: On the basis of Hanna's age-length standards, the mean summer kill of 1917–1919 consisted of 70 per cent 3-year males and 30 per cent 4-year males (Alaska Fisheries and Fur Seal Industries). On the basis of tooth-ridge counts, the mean summer kill, 1950–1952, consisted of 64 per cent 3-year males and 36 per cent 4-year males (Kenyon, Scheffer, and Chapman, 1954). But on the basis of Hanna's age-length standards, the summer kill of 1950–1952 consisted of 94 per cent 3-year males and 6 per cent 4-year males.

Now it is reasonable to believe that the ratio of three- and four-year males arriving on land during the killing season is naturally about two to one and that any measure that gives a different value is open to suspicion. Thus, the foregoing table clearly demonstrates that Hanna's age-length standards are no longer applicable to the male fur seal and that when a forcible attempt is made to apply them to present-day seals, the result is an exaggerated percentage of "three-year olds" in the report of the commercial kill.

INCREASE IN POPULATION

In the late 1800's and the early 1900's, the seal herd was reduced by over-killing to less than one-tenth of its estimated primitive size. Under terms of a treaty signed in 1911 the herd was given protection and immediately began to expand (Scheffer and Kenyon, 1952). The increase of the population up to 1930 is shown in Table 7. After 1930 the herd certainly grew to over a million animals, but the census method in use in the 'thirties and 'forties was giving, as we now realize, a false picture of the trend. A recent study (Kenyon, Scheffer, and Chapman, 1954) indicates that the herd entered its upper asymptote about 1940. Estimates of the size of the herd are: From tag recoveries, by the Peterson index, 1,840,000; from the trend of the annual harvest of bachelors, 1,670,000; from the trend of the annual count of harem bulls, 1,550,000. The first-listed is probably the most accurate. That is, the herd now numbers about 1.8 million animals, representing 4.3 times its size in the reference period 1913–1920 when Hanna and his associates were measuring seals from the 1912 brandings.

(In passing, it should be mentioned that, although the size of the total herd was not accurately estimated in the 'thirties and early 'forties, the trend quite certainly followed the direction of two counted elements within the herd, namely, the bachelors of harvestable size and the bulls. Both elements were counted annually. Their increase followed closely the Verhulst-Pearl logistic curve, flattening out in the early 'forties.)

While speculation upon the future of the herd would take us beyond the limits of this

TABLE 7.—*Increase in the Alaska fur seal population between 1911 and 1930*[1]

Year	Number of seals	Year	Number of seals
1911	123,600	1921	581,443
1912	215,738	1922	604,962
1913	268,305	1923	653,008
1914	294,687	1924	697,158
1915	363,872	1925	723,050
1916	417,281	1926	761,231
1917	468,692	1927	808,870
1918	496,432	1928	871,513
1919	524,235	1929	971,527
1920	552,718[2]	1930	1,045,101

[1] From annual reports, Alaska Fishery and Fur Seal Industries.

[2] The mean for the reference period 1913–1920 as used in this study is 423,278 seals.

paper, we venture to predict that the Pribilof population will never fluctuate far from its present level. Slobodkin (1953) concludes that "in general, social populations have a lower efficiency and higher stability than non-social populations." The important characteristics of fur seal behavior and ecology that may be supposed to contribute to population stability of the species are: (1) long life expectancy (maximum 30 years) and the coexistence of many adult age classes, (2) large genetic reservoir of nearly a million adults gathered at one place to breed, (3) fixed reproductive habits, namely, one young per litter, one litter per year, 1:1 sex ratio at birth, one brief season for breeding, (4) versatile feeding habits, that is, ability to utilize many species of squids and fishes, (5) extensive feeding range, about 2,000 miles from end to end, (6) uniform physical environment, the sea, (7) good health and remarkable freedom from epizootics, and, so far as known, (8) relative freedom from predation.

DISCUSSION OF LIMITING FACTORS

If the reader will agree, then, that the bachelor fur seal is smaller than his immediate ancestor and that the herd is asymptotic, let us consider what factors may have been responsible for limiting the size of the individual and the size of the population.

Food.—Seals feed on fish and squid, some seals foraging in winter and spring as far distant as the waters off Japan and northern Mexico. In view of the great expanse of feeding territory available to seals during the pelagic or nomadic phase of their annual life cycle, and the rarefied population, we conclude that the food supply in winter and spring is not an important limiting factor. In summer and fall, however, over a million seals rendezvous on two small islands forty miles apart in the Bering Sea. And although their feeding radius at this season is thought to sweep about 200 miles from the Pribilofs, we suppose that the average distance travelled by a seal in search of food is greater today than it was in 1913–1920.

The summer feeding habits of the bachelors and young bulls, the animals for which body size data are compared in the present paper, are virtually unknown. These growing animals probably shuttle between land and sea, increasing their length of stay on land as they approach breeding age at seven years. Fully adult males are known to remain on land without food or drink for over two months. Adult nursing females continue to feed throughout the summer and fall, often remaining at sea in July and August for eight or ten days while their suckling pups are on land (Bartholemew and Hoel, 1953). The feeding periods at sea probably lengthen through September and October until such time as the mother deserts her pup forever.

It is unfortunate that a Government taboo on the killing of female seals prevented Hanna from sampling females in the period 1913–1920. With comparable data on the change in body size of the male and female we would now be in a better position to estimate the influences at work upon the mean body size of *Callorhinus*.

The following reaction, then, is offered as one explanation of the asymptotic condition of the fur seal herd today: larger population → more intensive competition → greater average distance travelled by a half-million nursing mothers in obtaining food → longer intervals between nursing → less average weight gained by pups → higher pup mortality on land in the first summer and higher pup mortality at sea during the first critical winter.

Again, shortage of food around the Pribilofs in summer is perhaps the best explanation of the retarded growth rate of the seal. Whether the individual pup now gets a poorer start in life than it formerly did is a probability that can not be estimated from body size data. Pertinent data are lacking for pups and are of uncertain accuracy for yearlings. We are inclined to believe, however, from observation of increased mortality on land that the pups are in fact starting life with less body fat than they used to. At any rate, the bachelors and other seals older than pups are supposedly finding more difficulty in obtaining food than did their ancestors in 1913–1920.

Disease.—Mortality of pups in midsummer, by actual count, is now ten to twenty per cent, while in 1913–1920 it was only one to two per cent. The difference can plainly be as-

cribed to a sharp rise in the incidence of hookworm anemia (Olsen, 1952-1954; Alaska Fur Seal Investigations). (The hookworm organism has not been found in seals older than pups.) Reasons for the rise in incidence are speculative. Perhaps the newborn pup is slightly thinner and more vulnerable to attack (see preceding paragraph). Certainly the nurseries are now more crowded.

At this point we are reminded of the warning of Errington (1951): "the modern biometrician must be careful not to confuse with limiting factors those population by-products that occur incidental to, but with slight if any influence upon, the population status of a species. He must be careful not to confuse the *fact* of losses with *effect* of losses."

Virtually nothing is known about the pathogenic viruses, bacteria, protozoa, and fungi from whose attacks seals are presumed to have no special immunity, but from the evidence accumulated in a century and a half of fur-seal management, none appears to be of the slightest importance.

Predation.—There is no reason to believe that killer whales and sharks, the only observed predators of seals, have increased in numbers in the Bering Sea. Quantitatively, little is known about the effects of predation either now or in the earlier history of the seal herd. The current practice in management is to write off annually a certain percentage of seals as "lost at sea," until finally the books are closed on the last individual of a class at about age 30 (Scheffer and Wilke, 1953). Predation by man has remained very constant since the Treaty of 1911.

Effect of commercial killing.—Among the bachelor males the larger members of a given age class tend to arrive on land slightly earlier than their classmates. The June and July arrivals are traditionally killed for the market, while the August arrivals are spared as breeders. This practice has been criticized as responsible for slowly and steadily degrading the size of the seal. There is, however, a compensating practice. In screening the bachelors for individuals of commercially valuable size, the killers take virtually *all* of the June and July three-year olds, but only the *smaller* four-year olds. On logical grounds, the sparing of large "four's" should influence the male breeding stock more profoundly than sparing August (post-season) "three's", since the latter average only *slightly* smaller than their June and July classmates. If the influences as described have actually been in operation the net result should now be a larger fur seal. Since the opposite appears to be true (Tables 1 to 4), we suppose that the effect of commercial killing upon body size is either negligible or is outweighed by the effect of population increase. In line with this supposition we note that the practice of killing males in June and July has been carried on since 1870, and even earlier under Russian management. Hence, if any genetic change in size of the seal has resulted, it was probably initiated prior to the study period with which we are presently concerned.

Again, some have suggested that the commercial practice of killing only males on the Pribilofs has thrown the sex ratio so far out of balance as to lower the pregnancy rate. In other words, there may now be a shortage of bulls, especially young bulls. To accept this suggestion as fact one must assume that the killing of males in a crowded herd (1941–1952) had a retarding effect on population growth but did not in an uncrowded one (1913–1920). To be sure, many of the Pribilof breeding beaches, which formerly were not, are now filled to the limit in summer. From this observation we suppose that young, inexperienced males of breeding age may now have fewer opportunities for reaching the females than they did.

Recent studies (International Fur Seal Investigations, 1954) indicate that the pregnancy rate of the Alaska fur seal is only about 68 per cent. This is probably lower than it was in the era of rapid growth, 1911–1930, a deduction made from study of the Asiatic seal herd, thought to be still growing, where the pregnancy rate is over 80 per cent. Besides the *mean* discrepancy between American and Asiatic herds, biologists have found a *gradient*, with the discrepancy sharply defined in the three-year class. This is the youngest class in which female seals are able to conceive and the class where one would logically expect a disturbance in fertility first to announce itself.

We believe, then, that selective killing of males may have contributed slightly toward

depressing the pregnancy rate and thus toward halting the growth of the herd. More likely, the drop in pregnancy rate was automatic—a response to many factors including, perhaps, delayed attainment of sexual maturity. We do not believe that selective killing of males has contributed toward limiting the growth of the individual.

Social factors.—The class consciousness of seals and its problematic effect upon our data has been mentioned under sampling error. Frederick E. Smith has suggested (in letter) that, in view of the highly crowded shore life of seals and the aggressiveness of the male, it seems possible that social factors can be very powerful. Could not the extreme range of sizes found in the mature animals be due to dominance and submission? If so, a slight shift in the proportion of breeding males could throw the measures way off. The larger, dominant males could successfully enter the breeding arena, leaving their smaller classmates on the hauling grounds (bachelor country) to be picked up by the killing crew and later sampled by the biologist. This is a telling argument as applied to the young bulls, ages seven to eight years, on the threshold of breeding life. It would not seem to apply, however, to the juvenile and adolescent males, ages two to six years, which most of our data represent. These so-called bachelors spend their time in sleep and mock combat on the hauling grounds. At this stage in life they do not display the fierce aggressiveness of their elders.

It is possible, though very unlikely, that in recent years the tempo of mock combat and social play has increased among the bachelors to the extent that growth has been retarded among all individuals. We would rather believe that the bachelors instinctively dispose themselves on the beach in a gregarious pattern, the tightness of which is independent of the total number of animals present. Quite different is the phenomenon mentioned where the expansion of breeding units (harems) has squeezed out certain bachelor groups formerly scattered among them. We argue, then, that the bachelor expends no more energy on the beach today than he did in 1913–1920.

Summary of limiting factors.—We propose that the limiting factors in the growth of the fur seal population have been crowding and competition—more specifically (1) decreased summer food supply with increased mortality during the first year of life, and (2) decreased opportunity for breeding. Decreased summer food, in turn, has kept the body size of the seal from attaining its full potential. And hookworm anemia may have left its permanent mark in reduced body size, though this is doubtful.

The opinion of Dennis Chitty (in letter) is thought-provoking. "Your data on the fur seal might perhaps be interpreted as follows: A moderate amount of crowding is beneficial and probably essential both for maximum growth and reproductive rates. Prolonged overcrowding reduces the 'physiological tone' of the population and gives rise to generations which are constitutionally more susceptible to disease and may have reduced fertility. This may be all wrong, of course, but I cannot believe that your seals are short of potent males, nor do I think you have any evidence that there is a shortage of food."

Unfortunately, we have mustered all the evidence in view and can only trust that continued studies of the seal herd will bring support from over the horizon. Our inference that summer food is more difficult to obtain today than it was in 1913–1920 is not supported by facts and is frankly set forth as a working hypothesis. The kinds of facts that would help to solve the problem are listed below for the sake of discussion.

(1) A measured change in volume or quality of stomach contents in seals of the 1913–1920 period as against today. But the stomachs of seals on the breeding grounds are empty; and there exist no stomach records of seals taken from waters in the vicinity of the breeding islands either in the period 1913–1920 or in the recent period.

(2) A measured increase in the time interval between nursings, or an increase in the foraging radius of lactating seals. But comparative data for the earlier and the recent periods are lacking.

(3) A measured decrease in the average amount of fat (blubber) on the seals of today. Perhaps this would point to a food shortage; perhaps it would point to the effects of disease or overstimulation. In either event, while records of the mean weight of oil rendered from seals killed commercially are now being kept, they were not being kept in the period 1913–1920.

COMPARABLE STUDIES OF OTHER MAMMALS

Thirty papers dealing with quantitative aspects of body size with relation to population density among mammals have been selected for review. These may serve to emphasize the lack of, as well as the existence of, information on the elusive subject of our discussion.

THE BROWN RAT

Davis (1950) working with wild rats (*Rattus norvegicus*) in the city of Baltimore found that "after [an artificial] reduction in population the pregnancy rates and size of the survivors increased. Continuous removal of rats resulted in an increase in average weight of the remainder." As the environment was made increasingly favorable by the reduction of competition, the average body weight of the members responded.

In 1951, Davis reported a further attempt to analyze the relation of body weight and length to population level. His data are in two groups, one derived from city rats and one from farm rats. In the city, "analysis of the weight composition of 1,109 rats from stationary populations, 645 rats from increasing populations, and 380 rats from decreasing populations showed no differences." The stationary populations were on a natural plateau. The increasing populations were enjoying increasing food and shelter; the decreasing populations were suffering decreasing food and shelter. But in a sub-sample representing males only taken in periods of low reproduction he found that rats were significantly "heavier in the decreasing population than those in the increasing, but probably not than those in the stationary . . . Furthermore, the males were longer in the decreasing populations than those in either increasing or in stationary populations . . . While these data are only suggestive, they agree with the rather logical hypothesis that in decreasing populations the largest individuals survive, perhaps because of their high rank in the social order."

Among the farm rats, Davis found that the "population declined in a year from about 1100 rats to about 400 due to a gradual reduction in food and shelter. The population was apparently always at the capacity of the farm to support rats. Analysis of the weights of 2,181 rats captured during this period showed no relation to changes in population, although there were changes in average weight due to a large number of young in the period of high reproduction." (The rats that were sampled for weighing were released alive.) Here it would seem that the population changed so slowly that at no time was there an abrupt shift in the equilibrium between rats and their environment, that is, at no time did there develop crises sufficient to precipitate a change in body size.

The continuing studies of Davis and his associates upon rat populations are important. They are spotlighting the size: abundance relationship under various circumstances.

Calhoun (1950) designed an experimental environment in which food, shelter and protection from enemies were assured. He proposed to evaluate the importance of social pressure as a limiting factor in population growth He placed five pairs of wild brown rats in a large pen, at the center of which food was continuously available. He observed that the larger or more aggressive females selected nesting sites close to the food supply, whereupon a social gradient developed. Rats subsequently born at the periphery of the pen were forced to travel farther for food, and to make more frequent contact with adult rats. The peripheral rats "attained a lowered adult weight, were more frequently wounded in combat, and, though they conceived as often, rarely raised litters." Since greater weight is an important factor in combat, the poorer rats and their offspring tended to assume a lower social status and to remain as residents of the submarginal area. While the population had not reached its plateau when Calhoun assembled his preliminary findings, his data suggest how mammals may suffer growth-inhibiting effects from one another. These effects are density dependent, becoming sharper with increase of the population.

THE HOUSE MOUSE

In five laboratory cages of identical size, Crew and Mirskaia (1931) established albino mouse populations (*Mus musculus*) of varying density. Into the cages, 1 male was placed with 1 female, 2 with 2, 4 with 4, 8 with 8, and 12 with 12. Thus the initial populations

ranged from 2 to 24 mice per unit area. The cages were kept clean and were supplied with ample food; newborn young were removed as soon as they were found. "As time passed, it was noted that there was no difficulty in distinguishing an inmate of an 8 x 8 or 12 x 12 box from one of an 1 x 1, 2 x 2 or 4 x 4 box. The former was thinner, lighter, and more nervous. Yet all were equally well fed and clean . . . The degree of sexual activity endured by the individuals in the higher concentrations was distinctly higher than that of the lower."

"In order to find out if the offspring of females from the different densities differed among themselves, litters from each group were reared to puberty and beyond. It was found that the 8 x 8 and 12 x 12 offspring were smaller at birth than were those from the 1 x 1, 2 x 2, or 4 x 4; but that at the time of weaning (21 days), they were not to be distinguished from individuals out of the 1 x 1, 2 x 2, or 4 x 4 boxes; nor did they differ in respect to time of attainment of puberty."

Strecker and Emlen (1953) put 25 pairs of wild house mice in a pen provided daily with 250 grams of food, or about twice as much as the mice were able to consume. The experiment started in April. After a period of adjustment the mice began to multiply, their numbers rising rapidly through the summer months. By the end of August they were consuming the entire daily food ration. At this point they ceased to reproduce and the population started downhill, continuing its decline to the end of the trial in March of the following year. Compensating phenomena were observed. As the *total number* of mice declined, the per capita weight increased through growth of young mice into adults, with the result that the *total weight* of mice remained at a level during the last six months of the trial. The authors concluded that "no loss of weight or viability occurred, although the per capita consumption of food by adult mice was cut for a time by about one-fourth as a result of the increased number of animals." The authors suggest that, had the food ration been distributed several times daily rather than only once, greater opportunity would have been afforded for certain mice to become dominant. As a matter of fact, though, the "intake capacity" of the individual at a single feeding was limited, and all animals were able to obtain a fair share of food.

We accept with hesitation the statement that adult mice suffered no loss of weight during the experiment. We should like to see a comparison of the mean weights of full-grown mice sampled at monthly intervals. Manifestly, it would have been difficult at first to select for comparison adult animals of known age, but it should still be feasible to compare the mean weights of the heaviest quartile from each month's data. We assume, perhaps wrongly, that the heaviest quartile would include only full-grown animals.

THE VOLE

From long experience with vole populations (*Microtus agrestis*) in England, Chitty (1952) has concluded that body weight tends to be higher in a peak population than during either the decline or the early years of increase. In correspondence he has recently stated that "in the case of the vole it is quite certain that there is no food shortage except perhaps on rare occasions when an area is devastated. It is my belief that few species, under natural conditions, get anywhere near exhausting their food supplies."

In 1937–1939 he studied two populations in which adult males and adult females were unusually heavy during the peak year. In these instances, the rapid decrease in numbers that followed was thought to be caused by strife during the breeding season, with attendant derangements of the reproductive cycle.

To the best of our knowledge, no one has measured the growth rate of voles with reference to population density. Where a weight:abundance relationship has been demonstrated, it appears to be the vertical kind previously discussed, wherein average weight is determined by the survivors of a contest.

THE MUSKRAT

Dozier and Allen (1942) stated that "surprisingly little information is available on the average weights of muskrats." They examined over 9,000 adult muskrats (*Ondatra zibethica*)

from 27 trapping units on the Blackwater Refuge, Maryland, and found that "all units reported as poor in the abundance and quality of food plants yielded muskrats below the average weight for the refuge, and the poorest unit the animals lightest in weight . . . No correlation between weight and density of population could be found . . . ."

Dozier, Markley, and Llewellyn (1948) summarized the results of a study on the Blackwater Refuge in which over 23,000 muskrats were examined. "It is evident . . . that there is a direct correlation between size and weights of muskrats and the quality and abundance of their food supply. This is further substantiated by a study of several badly 'eaten-out' marshes that have shown a most significant progressive decrease in muskrat weights as the supply of food plants diminished, through the combined effect of over-population and inefficient trapping. Units 17, 18, 19, and 23 have produced the smallest adult muskrats on the entire Refuge during the period of this study. It is quite evident that this was due to over-population, which resulted in a radical reduction in available food supply and consequent serious 'eat-outs'."

We have prepared a scatter diagram (not shown) from the data in Dozier, Markley, and Llewellyn's Table 5, covering 20,800 muskrats of all classes trapped in 1941, 1942, and 1943. It points to an absence of correlation between average weight of muskrat and houses per acre, or abundance, on most of the trapping units. (Twenty-seven units were trapped for three years, giving a product of 81 case histories.) However, on two of the units (Nos. 18 and 19) there is a strong association between low weight and low population density. These two units are described as brackish areas poor in food plants.

We have carefully reviewed the figures applicable to units 18 and 19, covering a two-year period, and the figures applicable to four other units (6, 9, 10, and 27), covering a four-year period. Units 18 and 19 showed a decline in abundance and a slight decline in weight; the other units showed a decline in abundance and a slight increase in weight. Quite frankly, we are unable to see a pattern in these data, although we agree with the late Herbert L. Dozier that muskrats tend to destroy their own food supply and suffer a drop in weight.

Continuing studies on the Blackwater Refuge, Harris (1952) found that "the weights of male and female muskrats . . . were significantly higher in 1951 than during the period 1941 to 1945. This could be due to (1) increased numbers of larger and older muskrats because the refuge was not trapped during the two previous years [1949 and 1950], and (2) increased food per muskrat due to lower muskrat populations." We favor the first reason.

Aldous (1947) studied a collection of over 7,000 muskrat skins taken in South Dakota in April, 1944, and April, 1945. He compared average length of skin with abundance of muskrats on eight separate trapping units, and found no correlation (his Table 1; our interpretation). Abundance varied from 0.42 to 2.16 houses per acre.

Dozier (1950) summed up a six-year study of muskrats on the Montezuma Refuge, New York, during which time he examined approximately 30,000 muskrats. A good growing season produced more food and larger muskrats, while favorable weather brought greater trapping pressure and, in the following year, fewer older muskrats.

On the subject of body size in muskrats, Paul L. Errington writes (in letter) from long experience with furbearers in the marshes of north central United States. He feels that intolerance of crowding, with strife and occasional cannibalism, act more quickly to halt the growth of a muskrat population than do limitations of food. The same idea is expressed by Davis (1951) and Chitty (1952) and has been touched upon in our introduction, namely, that in a highly competitive population the larger individuals tend to survive. Subsequently, when a random sample is taken the dominant survivors bias the sample in the direction of greater weight. To demonstrate this interaction among muskrats one would need measurements of known-age animals by the scores. Up to now, no such data are at hand. Nevertheless, we suppose that, since older muskrats under trying circumstances are prone to kill younger ones, so also may the larger members of an age class destroy or drive out the smaller ones.

THE GRAY SQUIRREL

According to Chapman (1938) three game refuges in Ohio had been closed to hunting for twelve years, from 1923 to 1934. Gray squirrels (*Sciurus carolinensis*) attained population peaks at five-year intervals, that is, in 1925, 1930, and 1935. Starting in 1935, the refuges were opened for a 15-day hunting season each October, with the results indicated in Table 8. Although the sample was small and although we can not be certain that the squirrels lumped as "adults" were of comparable age, the increase in body weight between 1935 and 1937 appears to have been a genuine response to release of population pressure. Chapman's data are of special value because they were taken at the time of a population crisis.

TABLE 8.—*Body weight and abundance of gray squirrels, 1935–1937*[1]

Year	No. of squirrels weighed	Mean wt. of adult males, ounces	Mean wt. of adult females, ounces	Autumn population per 100 acres	No. of squirrels killed	No. of squirrels killed per hour of hunting
1935	120	16.8	16.9	10.8	2391	0.67
1936	36	17.8	17.2	2.3	284	0.16
1937	52	19.3	19.3	3.7	99	0.09

[1] After Chapman, 1938.

THE RACCOON

On the evidence of hunting success, raccoons (*Procyon lotor*) were increasing in Missouri between 1940 and 1948 (Sanderson, 1951). From 13,500 raccoons the take rose to 79,000. From 13.1 pounds the average weight of females dropped to 11.9, while that of males fluctuated gently.

Sanderson concluded that a decrease in food supply was not responsible for a decrease in body weight of females, for, if so, it would have affected the males likewise. He suspected that a rising percentage of parous females was responsible. Previous study had shown that the parous female, having nursed young, tends to be lighter than the nonparous. He concluded that "no one factor is alone responsible for the widespread irruption in raccoon numbers; however, the biological factors—changes in sex and age composition of the population in favor of more females and consequently more young—are enough to account for the irruption and are probably the major cause."

Crawford (1950) has pointed out an interesting link between large raccoons of both sexes and (a) high soil fertility and (b) high take by hunters, or abundance. Using 8,180 raccoons taken in 1941 and 1942 he has prepared statistically fitted curves to show relationships between soil fertility and raccoon harvest. He gives no tabular data.

DEER

In North American deer (*Odocoileus*) herds today nutrition, rather than hunting, predation, disease, unbalanced sex ratio, or catastrophe, is the most important factor in limiting population growth. Hence from a published reference to an "overpopulation," the reader may usually infer an overgrazed range and, conversely, from a reference to an overstocked or poor range, a recent irruption. The importance of food in toppling the balance of population is clearly expressed on the face of the abused environment—tree limbs denuded as high as a deer can reach and browse plants cropped to the bases of the coarser stems.

Most accounts of differences in body size of deer compare populations on adjacent or similar territories; few compare fluctuations in size within the same genetic strain. (Recall the phenotypical differences found by Davis, 1949, between city rats and farm rats.) For long-term, numerical data that satisfy the conditions listed in our introduction the reader will probably search in vain. A fair cross-section of published information on body size in

North American deer is given in the collected writings of Gerstell (1936), Johnson (1937), Cliff (1939), Park and Day (1942), Stoddart and Rasmussen (1945), Martin and Krefting (1953), and Latham (1953).

The data of Park and Day approach but do not satisfy our requirements. The authors examined over a thousand deer killed on the Allegheny National Forest during a four-year period, obtaining dressed weight and antler measurements. They also obtained in three of these years two additional body measurements; and in two years, a tail measurement. They based the ages of their specimens upon dental formulae. Unfortunately, the size of the population, 37,000 to 43,000, varied but little during the study period. The authors conclude that "actual genetic deterioration (body measurements), so far as could be ascertained from this study, does not occur before natural balances reduce the herd to normalcy." The reader may question whether a study thus limited in scope should be expected to produce immediate and significant evidence of genetic deterioration.

The history of white-tailed deer management in Pennsylvania has been summarized by Latham (1953). From an estimated 200 in 1907, the deer kill rose to an astounding 186,000 in 1940! "Annual kill averages, based upon five-year periods, since 1915 show that there has been a constant, and almost miraculous, increase in numbers, with no tendency toward a leveling off until [1945–1949]." Concurrently "the average body weight of deer has been retrogressing steadily for the past 20 to 30 years." The average weight of antlered bucks dropped from about 150 pounds to about 105. Fawns, taken alive in the wild from areas where adult bucks were averaging about 105 pounds hog-dressed, and reared in captivity on high-quality food, were found to weigh nearly twice this much by the third year. Antlers retrogressed in size and in number of tines.

MAN

Howard V. Meredith has kindly allowed us to reproduce in Table 9 certain data from a mimeographed summary of his publications (1941, 1943, 1944) on growth in man (*Homo sapiens*). "The greatest increases have been found during the childhood and adolescent years, with little change in adult size" (in letter).

According to the Population Reference Bureau (letter), the mean population of white males in the United States in 1860–1900 was 23,088,698 and in 1930–1950 was 60,833,423. Meredith's data cover North American white males while those of the Population Reference Bureau cover United States white males; the difference is unimportant.

Here is an example of increase in body size in a population that has been steadily increasing. At first glance the pattern resembles the increase in weight of voles in the ascend-

TABLE 9.—*Change at successive ages in mean stature (centimeters) of North American white males*[1]

Age	Period 1860–1900	Period 1930–1950	Difference	Per cent difference
Birth	50.4	50.7	0.3	0.6
1	73.8	77.1	3.3	4.5
2	81.6	86.9	5.3	6.5
4	96.5	103.4	6.9	7.2
7	114.3	122.4	8.1	7.1
10	129.6	139.2	9.6	7.4
14	151.8	163.7	11.9	7.8
17	166.3	172.9	6.6	4.0
19	172.1	175.6	3.5	2.0
25	171.8	173.5	1.7	1.0

[1] After Meredith; based on comparable ethnic and socioeconomic groups in the two periods.

ing phase of a cycle. Fundamentally, though, the North American white male has improved his nutritional environment through invention and labor, and at the present time his individual growth rate is little dependent upon population density. While there are those who predict the North American will tighten his belt during the asymptotic period of the century to come, others believe that a wider acceptance of family planning, rather than a shortage of food, will eventually halt the runaway growth of the population. It is quite likely, of course, that the body size of the individual will tend to be smaller in that approaching day as a result of increased nervous excitement—compare the behavior of the confined mouse and rat.

Coon (1939) remarks upon "the increase in stature which has affected northern and western Europe and much of the New World so profoundly within the last century." This change is ascribed to "changes in type and complexity of civilization," in other words, culturally motivated changes.

"Stature increases," he says, "may be matched with equally marked decreases. During the Dark Ages, from time of colonization to the sixteenth century, the Icelanders, originally as tall as their Norwegian ancestors, shrank in size to the stature of southern Italians. Climatologists now tell us that this shrinkage accompanied a lowering of mean annual temperature, and an increased dampness. Icelandic history adds that it was a period of near starvation. The Greenlanders, who suffered even more from this climatic change, became even smaller than the Icelanders before their extinction. Yet the Icelanders who survived this depression grew rapidly once it was over, until at present they comprise one of the tallest groups in Europe." (We are indebted to Stanley M. Garn for this reference.)

Change in stature of man during the Dark Ages seems to have been largely a density independent phenomenon. Per individual, the energy output required to maintain life in the face of increasing cold and decreasing food was high, resulting in a conservation of body size. On the other hand, population density may have modified the equation inasmuch as there was competition for the scant food available. Among North American white males today it may be said that competition for food is not a limiting factor in body growth.

Newman (1953) has reviewed certain evidence for the non-genic effect of the environment on body build, and while his conclusions are not new they are well phrased. "It seems clear," he says, "that body build is influenced by both hereditary and direct environmental factors. It is likely that the same environmental pressures that provide a selective screen favoring the better adapted body types, also make a somatic impression on the individual during his life span."

SUMMARY

GENERAL RELATIONSHIPS

Original data on body size with relation to abundance in the Alaska fur seal are presented. Selected references to the body size: abundance relationship in eight other species of wild mammals and in the albino house-mouse are reviewed. The objective has been to describe the influence of population pressure, through the environment, upon the body size of the individual. There appear to be three main environmental causes of reduction in body size: a decrease in food supply, an increase in disease, and an increase in nervous activity. The first two are density dependent in so far as they are created or favored by over-crowding. The third is almost always density dependent, that is, it rises out of the increased excitement of social and sexual contact. Among certain antisocial mammals increased nervous activity seems to bring increased mortality among the weaker, smaller, individuals; the net result being an *increase* in mean size of the survivors.

For clarification, two other kinds of variation in body size are mentioned. One is variation brought about by density independent factors such as weather, catastrophe, adventitious disease, or chance fluctuation in food supply. The other is a special kind of variation in "average body size," meaning only a change in average size brought about by a shift in the age composition of the population.

The difficulty of determining true age in study specimens has greatly handicapped investigations of the body size:abundance relationship.

BODY SIZE IN CROWDED POPULATIONS

The term "crowded" is used here to describe a population that has reached, or is approaching, the bounds of its environment and has ceased, or nearly ceased, to grow.

(1) The Alaska fur seal population increased 4.3 times between 1913–1920 and 1941–1952, and since the early 'forties has remained on a plateau. During the rise of the population the mean body size of the seal apparently decreased. For the six-year old male (sexually mature but only half grown) the percentage decrease in size was: weight, 25; body length, 11; basilar length, 6; and zygomatic width, 3. The percentage decrease in size showed a tendency to accumulate with age, suggesting that whatever the limiting factors, they were operative throughout life. Sampling errors were high. The rise in population began with the protective Treaty of 1911. Cessation of herd growth in the 1940's is ascribed, largely on circumstantial evidence, to increased mortality of young seals and to reduced rate of pregnancy. The decrease in body size is thought to be a primary result of competition among seals for food near the breeding grounds in summer. The decrease is correlated with, and may be partially linked with, a rise in the incidence of hookworm anemia. Hookworms, however, do not affect fur seals older than pups.

(2) In an increasing population of brown rats provided with surplus food and held in captivity, body weight decreased as a result of nervous excitement. The situation never became so critical as to precipitate cannibalism.

(3) In a city population of brown rats declining as a result of artificial reduction of food (whether artificial or natural is unimportant) there was an increase in size of males only. This phenomenon was attributed to survival of the larger males in a highly competitive and critical environment.

(4) In a farm population of brown rats declining as a result of natural reduction of food and shelter, no change in body size was observed at the end of a year. Here the rate of decline was apparently so gradual that the ratio of food supply to number of rats remained constant. It seems appropriate to consider this as a special case under crowded populations.

(5) House mice in captivity responded as did the rats in case 2; they decreased in size.

(6) Meadow voles were heaviest at population peak. The lightest individuals were presumably eliminated from the sampling reservoir by fighting and disease.

(7) The weights of over 100,000 muskrats have been recorded, along with reliable estimates of populations obtained through counts of 'rat houses or counts of trapper takes. Studies have been made of muskrat food plants and their growth response to fluctuating weather and salinity. The need has not been met, however, for a long-continued study, under careful control, of the effect of population pressure upon body size. In the present state of knowledge it appears certain that muskrats tend to destroy their own food supply and to suffer a decline in weight.

(8) In a raccoon population that increased about five-fold during an eight year period, the body weight of males apparently remained unchanged. Compensating factors in the environment or in the sampling technique are supposed to have produced this effect. (In other raccoon populations sampled at one level, that is, at one time, abundance showed a direct correlation with high body weight and high soil fertility.)

(9) Many deer populations have increased with the cultivation of land in North America. Deer tend to destroy their forage and to become emaciated. Numerical studies of deer have been handicapped by lack of age criteria, and the criteria or indices now available apply rather to physiological than to chronological age. As a result, there seem to be no published data from which body size:abundance formulae can be derived.

BODY SIZE IN UNCROWDED POPULATIONS

Here we might add, of course, the examples just given, since each crowded population has its precursor, an uncrowded one.

(1) In a city population of brown rats being thinned by trapping there was an increase in mean body weight.

(2) In a population of gray squirrels which was cut to one-third its size by hunting over a period of two years, the mean body weight in each sex increased about 13 per cent.

(3) The increased stature of North Americans and North Europeans in the recent century is the result of enlightened agriculture and nutrition and is thus far independent of population growth. Crowding is not yet a generally distributed and critical influence on body size. Body growth in man is especially sensitive to the stimulus of increased nutrition during the juvenile and adolescent years. Likewise, in the male fur seal nutritional influence increases with accelerated rate of body growth up to age six years, a subadult stage.

The stature of North Europeans decreased toward the end of the Dark Ages in a period of cold, wet climate. Presumably the population was also decreasing, but whether or not is unimportant in the present discussion. The changes in stature of man reviewed here seem to bear little relation to population density.

APPLICATION OF FINDINGS

Studies of body size with relation to population density in mammals have practical applications, first, to the wildlife management biologist and, second, to the systematic zoologist.

(1) Trend in body size, studied within age class and sex, and studied along with the physical aspects of the environment, is a clue to the underlying causes of population fluctuation. A shift in body size may mean a shift in the balance of food utilization against energy output. In so far as the shift is correctly measured and interpreted, the biologist is able to evaluate the respective influences of nutrition, predation, disease, fighting, shelter, and climate upon the objects of his investigation.

(2) Body size is, of course, not only a genetic product but a quantitative measure of environmental response. When certain body characters vary significantly in size from those of the generation closely removed, it may be argued that here are members of two "races" separated only by a thin partition of time. The argument is unrealistic but it does make a point: where slight differences are critical, the systematist should choose samples for comparative study taken from similar population density environments. This precaution extends the meaning of Cazier and Bacon (1949): "The specimens should be from similar climatic, edaphic, and biotic situations . . . taken within a limited range of time so as to preclude possible confusion resulting from contamination by seasonal variance."

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EMBRYO RESORPTION AND PLACENTAL SCAR FORMATION IN THE RAT

By Clinton H. Conaway

The purpose of this study was to investigate the formation of placental scars in the rat (*Rattus norvegicus*) uterus at the sites where embryos have been resorbed. The effects of different ages at embryo death, and of total and partial litter resorption have been studied to determine their relationship to placental scars of resorption.

The suggestion that placental scars are formed at the sites where embryos have been resorbed has been made by various workers. Davis and Emlen (1948) reported a study of multiparous laboratory rats in which the number of placental scars was compared with the number of young born. In 10 of 21 females there were more uterine scars counted than young born. This they ascribe to production of scars by resorbed embryos. Osborn (1953) found an average of 3.37 placental scars per female in 19 beaver (*Castor canadensis*) uteri. Embryo counts of 22 pregnant uteri gave an average of 2.91 embryos per female. Resorption involving one or more embryos was noted in six of the 22 uteri. He suggested that the resorption of embryos might account for the higher scar count in this species.

Very little direct information has been presented on the relationship of embryo resorption to placental scar formation. Brambell and co-workers (1948) make the following statement concerning resorption in the rabbit (*Oryctolagus cuniculus*): "The reabsorption sites remain recognizable as such macroscopically for 9–10 days after death from stilboestrol administration at either 11 or 15¾ days post-coitum; although the sites remain visible after that time, especially in the 15¾ series, it is not then possible to distinguish them from old post-partum placental sites." They made no further observation of the relationship between placental scars and embryonic resorption. Kerr (1947) in a study of the histology of early stages in the resorption of mouse (*Mus musculus*) embryos mentions that as resorption of 10-day-old embryos continues "cells and pigment are found much as in the pregnant spots which mark the position in normal uteri of previous placentae." Both of the above quoted statements indicate that resorption of embryos in the rabbit and mouse may result in the formation of scars. However no detailed studies of this subject have been made.

The placental scars of the rat appear as yellow to black pigmented areas along the utero-mesometrial border. Their origin seems identical with that of the scars in the mouse which have been studied by Deno (1937). He found that scars are produced by accumulations of hemosiderin in the cells of the reticulo-endothelial system that are associated with the involuting metrial gland. In both the rat and mouse, the metrial gland is a prominent structure at the base of the placenta, characterized by large glandular appearing cells. Presumably it is formed by an extension of the decidual response into the connective tissue of the myometrium. The pigment-laden cells are concentrated in this area between the longitudinal and circular muscle layers although some are found in the deeper stroma of the endometrium. As the age of the scar increases the pigmented area may decrease

in size and appear darker in color. Deno (1941) has noted such decrease in size of the scar in the mouse. However it has been shown that scars remain visible for at least a year in both the rat and the mouse (Deno, 1941; Davis and Emlen, 1948). Davis and Emlen (*loc. cit.*) also demonstrated that placental scars do not occur in virgin rats.

Procedure.—Virgin albino rats, three months or more in age, were used in this study. Estrus was determined by the lordosis response. Estrous females were placed in a cage with several males at about 9 PM and isolated the following morning. The day of isolation is considered as day one and all dating is from this reference point unless otherwise indicated.

Experimental embryo resorption was induced by the use of injections of a solution of powdered colchicine in normal saline. Kerr (1947) successfully used colchicine solutions to produce embryo death in mice. One milligram of powdered colchicine was dissolved in 2.5 cc. of physiological saline immediately prior to injection.

The females in one group were given a subcutaneous injection of colchicine solution. Prior to treatment an exploratory laparotomy was performed to record the number and distribution of embryos. A single injection of the colchicine solution was given either immediately after laparotomy or on the following day. The dosage found most effective was 0.27 cc. per 100 grams of body weight. A second laparotomy was performed two to four days after the injection of colchicine to determine the extent of resorption. Minor variations of this general schedule were used on some animals.

In a second group of females colchicine solution was injected through the uterine wall into individual gestation sacs at the first laparotomy. The dosage given to each treated gestation sac was 0.07 cc. of the solution described above. Usually only one or two embryos were treated. A second laparotomy was done in two or three days to determine the extent of resorption. This method was used with some success to produce resorption of only a portion of a litter.

One uterine horn was removed usually about 30 days after resorption of the litter, or 30 days after the birth of the surviving fetuses. The time of removal of the second uterine horn varied. Sometimes both horns were removed at the same time. The number and distribution of placental scars were recorded at the time of removal of the uterus. Uteri were pinned to the bottom of a dissecting pan and fixed in 10 per cent formalin. Measurements of the length and breadth of the placental scars in the fixed specimens were made with a filar micrometer and 30× magnification. The measurements were taken from the edges of the pigmented area, but frequently the boundaries of the scars were not sharply defined. In these instances selection of reference points for the measurements was somewhat arbitrary. Although every effort was made to treat the tracts uniformly it was impossible to pin them for fixation so that they were stretched exactly equally. Because of this error, measurements of scars in different uterine horns are only crudely comparable. Scars in the same uterine horn may be more critically compared with each other since it was possible to stretch a uterus equally throughout its length by placing pins only at both ends of the horn.

The formalin-preserved uteri were bleached in an aqueous solution of 2 per cent hydrogen peroxide for several days. This technique was found very effective if blood in the uterine vessels obscured the utero-mesometrial region. The color of the placental scars was unchanged by the peroxide treatment while the surrounding tissue was bleached, thus the contrast was greatly improved. Bleaching was especially useful if scars were faint. Clearing bleached uteri with wintergreen oil greatly increases the contrast of placental scars. This technique was not used routinely with rat uteri since the tissues are sufficiently thin to permit detection of the pigment without clearing. However placental scars of other species with thicker uteri can be much more clearly demonstrated by this method. It is especially helpful if the pigment is deposited in the endometrium. Routine bleaching of uteri of any species, followed by clearing if the tissue is thick, would probably be a worthwhile procedure to increase the accuracy of placental scar counts.

Paraffin sections of representative scars were prepared for microscopic study. Sections were cut at 8 micra and stained in hematoxylin and eosin.

A total of 136 experimental animals were used in this study, but results are presented for only 53 individuals. The remainder have been excluded for a variety of reasons. During the course of experimental procedures 41 animals died. Many of these losses occurred early in the study during the process of standardizing colchicine dosages. Seven animals were not pregnant at the time of the first laparotomy and were discarded. Some animals were eliminated because severe postoperative adhesions obscured the placental scars. When only one uterine horn was involved, data were obtained from the unaffected side. The remainder have been excluded because of other imperfections in the data, especially uncertainty as to the time of resorption or the failure to show resorption at the second laparotomy. Data from those animals not discussed do not in any way suggest differences in results from those presented.

RESULTS

Simultaneous total litter resorption.—Death of all of the embryos in a litter at approximately the same time followed by their resorption will be designated as simultaneous total litter resorption. All but two examples of this type of resorption were obtained by the use of subcutaneous injections of colchicine although many animals so treated did not resorb in this way. In two animals all gestation sacs were directly injected with colchicine.

The results obtained by the use of subcutaneous injections of colchicine were not always satisfactory. Loss of some females resulted from use of the drug, apparently because of low thresholds of sensitivity. A major difficulty, however, was that there was obvious variation in the times at which fetal death occurred. Occasionally some of the gestation sacs appeared normal at the time of the second laparotomy while others were being resorbed. If some living young were born, these animals have been included with those data in the section under partial litter resorption whenever the information was sufficiently precise to make it of value. If no living young were born, the animals are discussed under the section on prolonged total litter resorption.

Animals in which all of the embryos were resorbing at the time of the second

laparotomy showed only slight variation in the appearance of the gestation sacs in any individual female. This would indicate that all embryos of the litter had died at about the same time. There was however, considerable variation between females with regard to the appearance of the gestation sacs at the second laparotomy. Apparently this was due to variations in the time interval between injection and embryo death as well as between injection and the second laparotomy. It was therefore necessary to estimate the day of fetal death by evaluating the size and appearance of the gestation sacs at the time of the second laparotomy.

Since the time between the first and second laparotomies was usually between two and four days, the maximum resorption noted was assumed to indicate that embryo death had occurred shortly after the first laparotomy. Thus if the uterine lumen was clear of detritus and only the metrial gland area was visible at the implantation sites it was assumed that embryo death had occurred at least three days prior to examination. If the uterine lumen was swollen, filled with dark material and the gestation sacs not discrete this was taken to indicate that embryo death had occurred one to two days earlier. If the gestation sacs were discrete swellings but dark, it was assumed death had been recent.

While the day on which embryo death occurred can only be estimated, a period

TABLE 1.—*Total litter resorption*

Animal no.	Day of 1st laparotomy	Day of colchicine injection	Day of 2nd laparotomy	Estimated day of resorption	Right Tract			Left Tract		
					No. of embryos	Day uterus removed	No. of scars	No. of embryos	Day uterus removed	No. of scars
95	8	8	12	8	7	36	0	2	66	0
103	8	8	9	8	4	36	0	4	36	0
18	9	9	11	9	7	30	0	3	30	0
61	8	8	11	9	4	47	0	4	97	0
1–5	9	9	12	9	7	36	0	3	36	0
1–6	9	9	10	9	4	38	0	4	38	†
2–4	10	10	13	10	4	51	†	4	51	0
96	8	8	12	11	1	36	0	7	91	6
87	9	10	12	11	7	30	5	3	85	3
3–6	11	11	12	11	8	40	8	4	92	4
101	9	10	13	12	5	45	5	5	77	5
1–2	10	10	13	12	6	42	†	3	42	3
1–8	10	10	14	12	4	41	†	4	41	4
72	12	12	14	13	5	47	5	4	107	4
38	11	12	15	13	5	31	5	6	95	6
37	11	12	15	14	4	40	4	6	104	6
62	12	12	16	14	3	108	3	7	48	7
45	15	15	17	15	5	41	5	7	41	7
53	15	15	17	15	7	47	7	7	47	7
66	14	15	17	16	3	46	3	3	100	3
54	15	15	18	16	6	46	6	2	46	2
46	14	15	21	18	10	44	10	2	110	2
M-3*	9	9	13	10	2	60	0	0	60	0
M-20*	8	8	11	9	2	62	0	0	62	0

* All embryos directly injected with colchicine

† Adhesions

of several days can be given during which embryo death must have occurred. A conservative delimiting of this period would be from the time of the first laparotomy until the second. It is probably reasonable to further confine this period to the time between colchicine injection and the second laparotomy. It is possible that early natural resorption might have occurred and it might not have been recognized at the time of first laparotomy. However it is highly improbable that this happened with any great frequency.

The data from animals in which entire litters were resorbed are summarized in Table 1. These results show that when embryo death occurred between the seventh and tenth days of pregnancy, resorption followed without the formation of placental scars. The results obtained in the three animals in which all embryos were estimated to have died on the eleventh day of pregnancy are variable. Placental scars were formed at 26 of the 30 resorption sites involved in this group. No scars are visible at four of the implantation sites. Embryo death occurring on the twelfth day or later always resulted in the formation of a placental scar at the resorption site (1, 2, Pl. I).

The scars of resorption were compared with those found in normal parous uteri in an attempt to determine whether or not the two groups were distinguishable. No criterion for differentiation was found. The color varied between pale orange and black in both groups. Newly formed scars were orange and those that had been formed for a considerable time were darker. However the rate at which the scars darkened was highly variable. Frequently, both in parous and experimental animals considerable color variation was noted in adjacent scars in the same uterine horn. Measurements of the size of the placental scars show that this character is of no value in differentiating those formed at resorption sites from those formed at normal embryo sites, although scars formed at sites where resorption began on the eleventh day are often smaller than those formed at later resorption sites. Usually these scars are also noticeably fainter than those of later resorption, apparently due to the deposition of less pigment in the scar area. These differences are transient and variable so that they are of no value in distinguishing scars of resorption. There is no apparent difference in size between scars in uteri of those animals in which resorption occurred after the twelfth day and those in parous uteri. Extreme variation in size with complete overlapping of range is apparent in both groups.

Comparisons of sizes of placental scars in different uterine horns are of doubtful significance since the horns could not be uniformly stretched before fixation. The data concerning measurements of scars discussed in this section are therefore not presented. More reliable data for comparing scars at resorption sites with those at normal sites are given in the following section.

Partial litter resorption.—This category includes those females in which one or more embryos were resorbed while the surviving young were carried to term and delivered. Most examples of partial litter resorption were obtained by making direct injections of colchicine into some of the gestation sacs at the time of the first laparotomy. The appearance of the injected gestation sacs at the second laparotomy indicated that embryo death must have occurred very shortly after

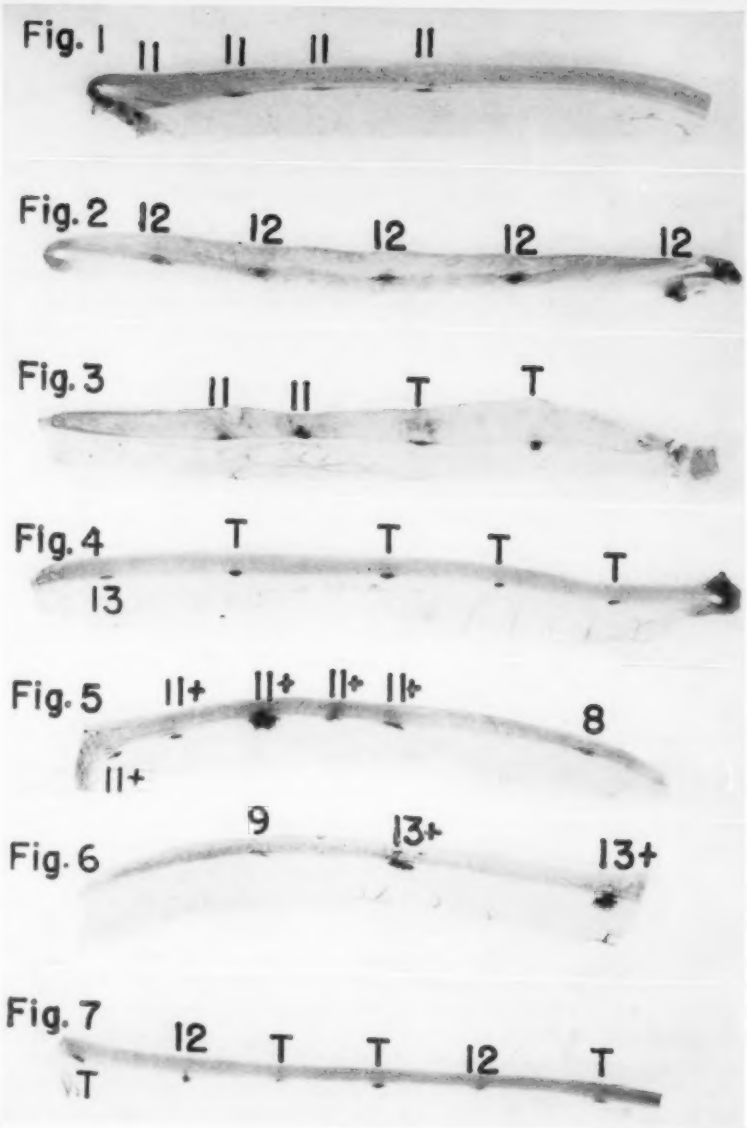

PLATE I

Gross appearance of uteri showing placental scars. Uteri were cleared in wintergreen oil and photographed with transmitted light. The symbols above each scar indicate the origin of the scar. T = term embryo site. Numerals indicate estimated day of resorption. Wratten 39 filter. ×1.25.

1. Left uterus of No. 3-6. Simultaneous total litter resorption day 11. Uterus removed day 92.
2. Right uterus of No. 101. Simultaneous total litter resorption day 12. Uterus removed day 45.
3. Right uterus of No. 36. Partial litter resorption. Uterus removed day 55.
4. Left uterus of No. 56. Partial litter resorption. Uterus removed day 114.
5. Right uterus of M-14. Prolonged total litter resorption. Uterus removed day 60.
6. Left uterus of M-2. Prolonged total litter resorption. Uterus removed day 62.
7. Left uterus of No. 42. Partial litter resorption in untreated animal. Uterus removed day 106.

TABLE 2.—*Partial litter resorption*

Animal no.		Day 1st lap.	No. emb.	No. Treated	Day 2nd lap.	No. resorb.	Est. day of resorp.	No. born	Day Uterus Removed	No. Scars
M27	R	7	4	1	11	1	7	2	76	4
	L		6	1		2	7		53	6
M5	R	8	4	0	11	1	8	2	90	4
	L		6	1		2	8		48	6
M18	R	8	5	1	11	5	8–10	1	50	5
	L		10	1		9	8–10		50	10
M21	R	8	5	0	10	0	8	6	82	5
	L		6	1		1	8		82	6
M23	R	8	7	1	14	6	[1]	5	80	7
	L		5	1		1	12		80	5
M24	R	8	6	1	14	2	[2]	8	80	6
	L		4	0		0			30	4
M26	R	8	11	0	12	0		2	75	11
	L		4	1		3	[3]		75	4
3	R	9	6	2	12	2	9	2	43	6
	L		5	2		2	9		73	5
M10	R	9	10	1	13	3	11	4	50	10
	L		3	1		1	9		50	3
M16	R	9	7	1	12	2	[4]	7	49	7
	L		6	1		1	9		88	6
M25	R	9	3	1	13	2	9	4	79	3
	L		3	0		0	9		79	3
4–6	R	10	6	1	12	1	10	6	52	6
	L		5	1		1	10		52	5
1	R	10	4	1	13	1	10	2	51	4
	L		8	1		1	10		51	8
5–6	R	10	5	1	12	1	10	6	60	5
	L		6	1		1	10		60	6
5–8	R	10	5	1	12	1	10	7	60	5
	L		6	1		0			60	6
36	R	11	4	1	13	2	11	7	55	4
	L		5	0		0			55	5
50	R	14	5	[5]	16	5	14	1	53	5
	L		5			4	14		53	5
56	R	13	5	[6]	16	1	13	8	50	5
	L		5			1	13		114	5
71	R	14	2	[7]	17	1	15	3	114	2
	L		5			3	15		114	5
67	R	13	5	[8]	16	2	15	4	46	[9]
	L		4			3	15		106	4

[1] 3 on 8th, 2 on 10th, 1 on 12th
[2] 1 on 8th, 1 on 10th.
[3] 2 on 8th, 1 on 10th.
[4] 1 on 9th, 1 on 10th.
[5] subcutaneous injection day 14
[6] subcutaneous injection day 13
[7] subcutaneous injection day 14
[8] subcutaneous injection day 14
[9] adhesions

treatment. Frequently gestation sacs adjacent to those treated also were being resorbed at this time. Females were permitted to nurse the surviving young for three weeks.

Placental scars were formed at resorption sites in all cases if embryo death occurred on the seventh day of pregnancy or later (Table 2). This is in contrast to the results obtained when entire litters were resorbed. It has been shown above, that in simultaneous total litter resorption placental scars are not formed at resorption sites if embryo death occurs prior to the eleventh day of pregnancy. Sufficient material is available from both groups to suggest that the difference is real. However such a conclusion must be tentative since the time of embryo death could not be precisely determined in either group.

Only a portion of the experimental animals can be used for comparison of the scars at resorption sites with those at normal embryo sites. The useful data are from those animals in which the number born plus the number known to be resorbing at the second laparotomy was equal to the total number of embryos recorded at the time of injection. Often the number born was less than the number of viable embryos recorded at the second laparotomy. Some of these discrepancies possibly were attributable to females eating newborn young, however the major cause was apparently additional resorption after the second laparotomy. In such cases it was not known which scars were the sites of term embryos.

The usable material is especially suited for making comparisons between the scars formed at resorption sites and those at normal sites since the two types of scars usually are adjacent in the same uterine horn. The color of both types of scars was extremely variable and of no value in determining their origin. The measurements of the scars are given in Table 3. They show that size cannot be used to differentiate the two types of scars. As in simultaneous total litter resorption the scars formed by resorption early in pregnancy (before day twelve) tend to be smaller and especially fainter, but even this is not constant (3, 4, Pl. I).

Prolonged total litter resorption.—This class includes those animals in which all embryos were resorbed but the individual embryos died at various ages during gestation. Resorption of this type occurred in some animals of both the subcutaneously injected and direct embryo injected groups of colchicine treated females. At the second laparotomy it was apparent that some embryos were being resorbed while others were viable. Following the laparotomy, routine palpations indicated roughly the condition of the remaining embryos. Resorption of these embryos was estimated in some cases to have begun shortly after the second laparotomy. Frequently some of the fetuses appeared to remain viable until near term. Degenerating fetuses have been palpable as late as 25 days after copulation. In such cases of late resorption considerable vaginal discharge of detritus occurred through several days.

Many of the animals falling into this class contribute no additional information and these data are not presented. In a small group some of the embryos are known to have been resorbed between the eighth and eleventh days of gestation while others remained viable until after the twelfth day. The results from this group (Table 4) are of interest to compare with those presented in previous sections.

TABLE 3.—*Size of placental scars in partial litter resorption*

Animal no.	Est. day resorp.	Day uterus removed	Size resorp. scar (mm.)		Size term scar (mm.)	
			Length	Width	Length	Width
M18 L	8–10	50	1.3	.3	1.3	.5
			1.3	.4		
			1.3	.3		
			1.1	.3		
			1.1	.5		
			1.2	.5		
			1.2	.5		
			1.1	.7		
			1.1	.5		
M23 R	8	80	1.2	.5	1.3	.5
			1.1	.6		
			1.2	.7		
	10		1.6	.2		
			1.7	.3		
	12		1.5	.5		
M23 L	12	80	1.2	.3	1.3	.3
					1.5	.3
					2.1*	1.6*
					1.3	.4
M25	9	79	1.3	.4	1.3	.5
			1.3	.5		
M24 R	8	80	1.3	.5	1.3	.4
					1.6	1.1
	10		1.1	.5	1.2	.3
					1.6	.2
3–6 R	11	55	1.1	.5	1.4	.3
			1.3	.5	1.2	.3
56 R	13	50	1.1	.5	0.5	.5
					1.1	.5
					1.1	.3
					1.6	.5
56 L	13	114	.7	.5	1.1	.2
					1.1	.5
					1.0	.5
					1.0	.2
50 L	14	53	1.6	1.1	1.5	.8
			1.5	.7		
			1.5	.7		
			1.4	.8		
71 R	15	114	.5	.6	1.0	.5
71 L	15	45	1.3	.3	1.9	.3
			1.4	.4	1.5	.3
			1.9	.5		
67 L	15	106	.7	.5	1.0	.2
					1.0	.5
					1.0	.5
					1.0	.2

* The metrial gland at this site was atypical and enlarged at laparotomy.

TABLE 4.—*Prolonged total resorption*

Animal no.		Day 1st lap.	No. emb.	Day of colchicine injection	Day 2nd lap.	No. emb. resorbing at 2nd lap.	Estimated day earliest embryo death	Estimated day latest embryo death	Day uterus removed	No. scars
M4	R	9	6	9	11	4	9	14	62	6
	L		4			4	9		62	4
M13	R	8	2	8	11	2	8	20	60	2
	L		8			0			60	8
M14	R	8	6	8	11	1	8	21	60	6
	L		2			1	8		60	2
M2	R	9	4	9	13	4	9	15	62	4
	L		3			1	9		62	3
M12	R	9	3	9	12	2	9	20	61	3
	L		4			0			61	4

TABLE 5.—*Resorption in untreated animals*

Animal no.		Day 1st lap.	No. emb.	Day 2nd lap.	No. emb. resorb.	Est. day resorb.	No. born	Day uterus removed	No. scars
92	R	14	4		4	12–14	0	51	4
	L		5		5	12–14		107	5
74	R	12	9	17	1	15	10	54	9
	L		2		0			114	2
42	R	14	4		1	12	7	45	4
	L		6		2	12		106	6
40	R*	15	4 (1 resorb.)	19		1 on 12th	4	52	5
	L*		3 (4 resorb.)		3	4 on 12th 1 on 15th 1 on 16th 1 on 18th		116	7

* See text for explanation.

TABLE 6.—*Size of placental scars in untreated animals*

Animal no.		Day uterus removed	Est. day resorp.	Size resorp. scars (mm.)		Size term scars (mm.)	
				Length	Width	Length	Width
74	R	54	15	1.5	.5	1.3	.8
						1.5	.7
						.6	.6
						1.6	.7
						1.3	.5
						1.3	.5
						1.4	.6
						1.6	.7
42	R	45	12	1.3	.3	.7	.2
						.6	.5
						1.1	1.0
42	L	106	12	.5	.2	1.3	.5
				1.3	.5	.8	.6
						1.0	.3
						1.3	.5
40	R	52	12	.9	.5	.8	.3
						.6	.9
						.6	.8
						.5	.5

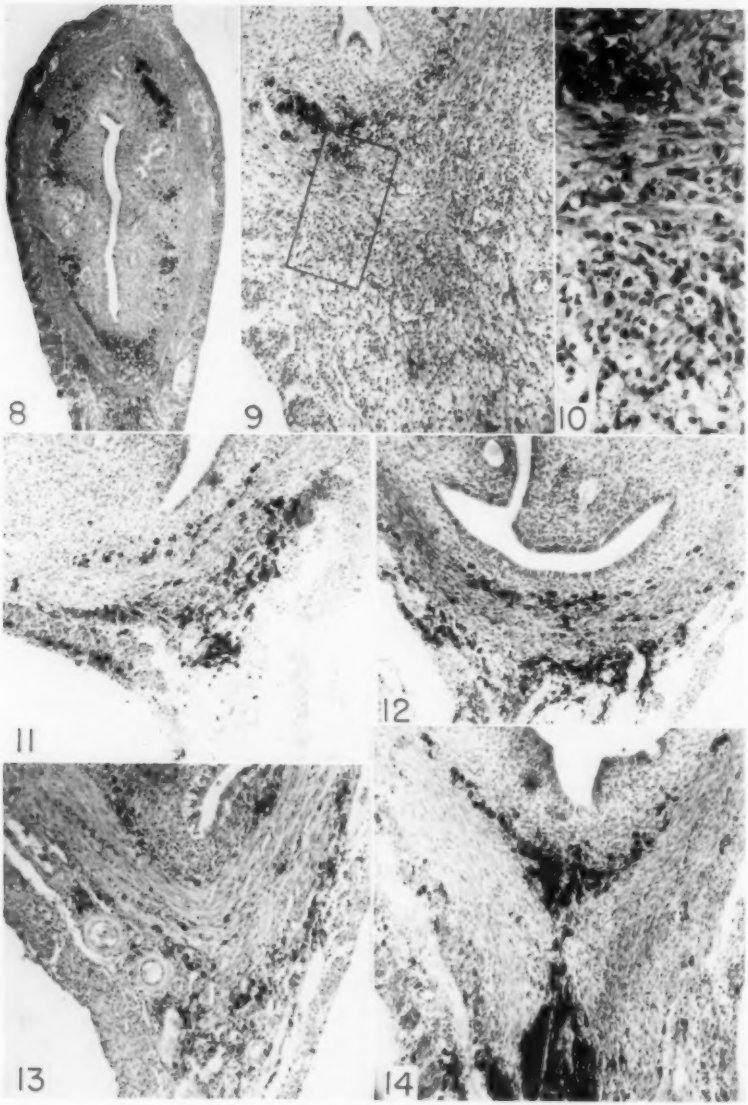

PLATE II

Photomicrographs of cross sections of uteri through placental scar areas. H. and E. stain. Wratten 39 filter.

8. Right uterus of No. 54. Total litter resorption day 16. Uterus removed day 46. Large pigment granules are distributed in cells of the deep mucosa. The metrial area is hypertrophied and the cells contain small pigment granules. ×52.

9. Mesometrial area of right uterus of No. 37. Total litter resorption day 14. Uterus

The results show that if some embryos die between the eighth and tenth day while others remain viable until later pregnancy placental scars are formed at all of the resorption sites. Thus the relationship between age at embryo death and placental scar formation is as in partial litter resorption rather than in simultaneous total litter resorption. The size and appearance of the placental scars (5, 6, Pl. I) are also comparable to similar stages of partial litter resorption.

Resorption in untreated animals.—Naturally occurring resorption was encountered in four animals. One of these was an example of total litter resorption and the other three were cases of partial litter resorption. One of the latter (animal #40) provides especially good data for making comparisons of the scars formed at resorption sites with term scars. This animal was first laparotomized on the fifteenth day of pregnancy at which time one resorption site and four normal embryos were seen in the right horn, while four resorption sites and three normal embryo sites were present in the left horn. The age at death of the five resorbing embryos was estimated to have been day 12. At a second laparotomy on day 19, all four embryos of the right horn were normal while the three on the left side, which had appeared normal at the first laparotomy, were in various stages of resorption. The ages at embryo death were estimated as day 15, 16 and 18. On day 21 four young were born normally. Therefore in this animal there was considerable variation in the ages at which resorption began, and these sites as well as the sites occupied by term animals are known. Data from the four untreated animals are summarized in Tables 5 and 6.

Comparisons of the material from untreated animals with similar specimens from the colchicine treated series showed no difference in the appearance of the scars (7, Pl. I). No examples of any type of resorption in animals prior to day 12 were obtained. Possibly in early pregnancy a difference might be found in the relationship of resorption to scar formation in untreated as compared to colchicine treated animals. However the similarity between the scars of the two groups when resorption occurred in late pregnancy supports the assumption that the use of cochicine to induce embryo death does not produce any unique effect on the placental scars. It seems valid to use the experimental findings to predict the results that would be expected in natural resorption.

Histology of scars.—Sections of representative term and resorption scars were examined to determine if there were distinct microscopic differences between the

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removed day 46. Large pigment granules in mucosa. Small scattered granules in hypertrophied metrial gland area. ×135.

10. Indicated segment of 9 enlarged to show pigment laden cells in circular muscle stratum. Note pigment granules of mucosa and metrial gland area. ×285.

11. Mesometrial area of right uterus of M-18. Partial litter resorption. Uterus removed day 50. Resorption day 8 at site shown. ×135.

12. Mesometrial area of right uterus of M-18. (See 11.) Resorption day 10 at site shown. Large pigment granules are deposited in both the mucosa and metrial gland. ×135.

13. Mesometrial area of left uterus of No. 37. Total litter resorption day 14. Uterus removed day 104. Few pigmented cells remain in the mucosa. Large granules are present in the involuted metrial gland. ×135.

14. Mesometrial area of right uterus M-18 (see 11). Term embryo site. Unusually heavy and concentrated pigment deposition in both the mucosa and metrial gland region. ×135.

two types of scars. Scars of various ages were also studied in order that involutional changes could be separated from any other differences that might exist.

The involutional changes that occur in the rat placental scar are much like those of the mouse as described by Deno (1937). The major difference is that in the rat regression occurs more slowly. Deno (1937) indicates that in the mouse at 16 days post-partum "the macrophages which formerly extended throughout the wall of the placental site now are found chiefly in the outer half and extend into the mesentery." By 24 days post-partum "the only indications of the placental site are the hemosiderotic areas at the base of the broad ligament." Rat placental scars at 20 to 30 days post-partum still have many pigment laden cells in the deeper endometrium and they are particularly concentrated in the endometrium adjacent to the broad ligament. The pigment granules contained in these cells are distinctly larger and more closely packed than those of the mesometrial macrophages which at this stage have fine, scattered granules (8, 9, 10, Pl. II). Some pigment cells persist in the mucosa until at least three months post-partum.

The fate of the mucosal macrophages is not clear. The appearance of scars taken at 20 to 30 days post-partum suggests that some of these cells move outward through the circular muscle layer into the mesometrial region. Frequently the circular muscle in this region is interrupted completely so that the pigment cells external and internal to it form a continuous mass. In other cases pigment cells occur between muscle cells in this area and may be interpreted as migrating. The number of pigmented macrophages in the mucosa obviously decreases as involution progresses (9, 13, Pl. II) and it seems likely this is due to their migration and concentration in the mesometrial area.

The macroscopically visible darkening of the placental scars that occurs with regression is correlated with changes in the pigment granules and macrophages. The pigment cells become more closely packed and decrease in size. The granules within the cells are also much closer together and many more large granules are seen than in early stages of involution. The color of the individual granules does not seem to become darker in the material examined. There is much variation in the rate at which the changes occur in different animals and in different scars of the same set in an individual rat. Such differences are reflected in the great macroscopic variation previously noted.

Comparisons of the placental scars of resorption with those of term embryos show that they are similar. Scars formed at early resorption sites (11, 12, Pl. II) usually have fewer pigment laden cells than term scars (14, Pl. II). This difference is slight compared to individual variation and regression changes. It is not of value in distinguishing scars of early resorption in material for which the history is not fully known. No differences were found between the scars of later resorption and term.

DISCUSSION

The data indicate that there is a difference between simultaneous total litter resorption and both partial litter and prolonged total litter resorption with regard to the earliest stage of pregnancy at which embryo death can occur and still

result in placental scar formation. If the entire litter is resorbed, placental scars are formed when all of the fetuses die on about the eleventh day of pregnancy or later. If only a part of the litter is resorbed or if some embryos remain viable until later in pregnancy, placental scars are formed when embryo death occurs as early as the seventh or eighth day of pregnancy.

All cases of early partial litter and prolonged total litter resorption were obtained by making direct injections of colchicine into individual gestation sacs. The majority of examples of simultaneous litter resorption were produced by subcutaneous injections of colchicine into the pregnant females. However in two animals simultaneous total litter resorption on the ninth and tenth days was produced by directly injecting all gestation sacs. Scars were not found at these sites, while they were found at comparable sites if either prolonged total or partial litter resorption occurred. This suggests that the observed difference in the relationship between age at embryo death and scar formation was not due to technique. The number of animals available in the critical early stages and general uniformity of results during this period support the conclusion that there is a real difference. An explanation of this difference can be postulated by considering the relationship of the placental scar to the metrial gland and the hormonal control of the metrial gland.

The metrial gland of the rat develops beneath the placenta in the area between the circular and longitudinal muscle layers. Baker (1948) has studied the development of this structure. He found that the metrial gland first begins to develop on the sixth day of pregnancy when connective tissue cells hypertrophy, become hyperplastic and show basophilia. By the ninth or tenth day eosinophilic granules appear in these cells. The peak of development is reached between the thirteenth and fifteenth day. Involution begins about the seventeenth day. Lipids increase steadily throughout involution and in the early post-partum period.

Pigment granules begin to appear in the metrial gland area shortly after parturition. The majority of the pigment is hemosiderin (Deno, 1940) although lipochrome may occur (Baker, 1948). The pigment is collected in macrophages that are of uncertain origin. The size of the metrial gland decreases rapidly during the post-partum period so that only the pigmented spots remain by 24 days post-partum in the mouse (Deno, 1937).

The effects of steroid hormones on the metrial gland have been studied by several workers. It is apparent that progesterone acting on an estrogen-sensitized uterus is required for the formation of deciduae and the metrial gland (Selye and McKeown, 1935). Progesterone appears to be responsible for the maintenance of these structures. Continuous treatment of castrate female rats with 4.5 milligrams per day of progesterone will maintain the metrial gland of deciduomata until the eighteenth day (Velardo *et al.*, 1953). Other steroid hormones seem to have little or no effect (Masson *et al.*, 1942).

The difference in effect of age at embryo death on placental scar formation in partial and prolonged total litter resorption as compared to simultaneous total litter resorption may be due to the relationship of progesterone to the metrial gland. In partial litter resorption, progesterone levels would be maintained by

the remaining functional placentae and the corpora lutea. Presumably the metrial glands and deciduae would also be maintained longer than they would be if all embryos were resorbed. Preliminary experiments have shown that placental scars will be formed at the sites of deciduomata in the non-pregnant horns of unilaterally pregnant rats. Therefore it would be expected that maintenance of the metrial gland and deciduae would effect the formation of the scar. In contradistinction the absence of functional placentae and termination of pregnancy in total litter resorption would be expected to result in lowered progesterone levels. Then the metrial gland may involute before reaching the stage necessary to produce macroscopically visible scars.

The number of embryos surviving beyond the twelfth day does not seem to be a factor influencing the development of placental scars at the sites of earlier embryo resorption. In one example of partial litter resorption (Table 2, no. M-18), 14 of 15 embryos were resorbed between the eighth and ninth day of pregnancy so that only a single young was born. Scars were visible at all 15 sites in this specimen. Similarly in one case of prolonged total litter resorption (Table 4, no. M-4) only two of ten embryos survived beyond the ninth day and these were estimated to have died by the fourteenth day. Placental scars were found at all ten sites.

The placental scars formed at resorption sites cannot be distinguished from those formed at the sites of normal embryos. Scars formed by resorption early in pregnancy are usually somewhat smaller and less distinct than those of resorption after the twelfth day of pregnancy or of normal embryos. However individual variations in the size and color of scars is so great that even scars of early resorption cannot be certainly differentiated. It is interesting to note that the metrial gland reaches its maximum development on about the thirteenth day of pregnancy. This may explain the similarity between scars of later gestation resorption and scars of term embryos. The formation of a placental scar seems dependent upon the establishment of decidua and a metrial gland rather than on the presence of an embryo and placenta.

Considerable use has been made of placental scar counts as criteria of the productivity of various mammalian species. This technique seems most useful in monestrous forms. It has been used with some success by Sanderson (1950) in raccoon (*Procyon lotor*), Sheldon (1949) working with foxes (*Vulpes fulva*, *Urocyon cinereoargenteus*), and by Osborn (1953) in beaver. The rapid successions of litters in polyestrous forms results in the formation of large numbers of placental scars of several generations. Davis and Emlen (1948) have shown that in multiparous rats the number of young born may be considerably in excess of the observed number of placental scars. They attribute this discrepancy to superposition of successive placental sites or fusion of the scars. Their studies, and those of Deno (1941), have indicated that the scars do not rapidly regress with time in the rat, since they remain clearly visible for at least one year. In the uniparous rats used in this study only one generation of scars was present. The number and distribution of placental scars was always equal to the number of viable embryos present on approximately the eighth day or eleventh day of pregnancy depending on the type of resorption that occurred.

The mechanism of placental scar formation is probably similar in species showing pigmented spots at the placental site. It is reasonable to expect that placental scars will be formed in such species at resorption sites as they do in the rat, although the relationships between age at embryo death and placental scar formation may differ. Therefore calculations of productivity made by the use of placental scar counts may overestimate the number born if resorption occurred.

Embryo resorption is known to occur in many species and frequently the percentage of resorption is high (Brambell, 1948). Resorption rates may also vary markedly in different populations of the same species (Atwood, 1950; Brambell, 1948). The evidence suggests that in the rat (Perry, 1946), the rabbit (Brambell, 1948), and the mouse (Hollander and Strong, 1950), partial litter loss occurs randomly throughout gestation. Total litter loss after implantation is less common in the rat than is partial litter loss (Perry, 1946). In the striped hamster (*Cricetulus griseus*) both types of embryo loss commonly occur (Fortuyn, 1929). Total litter loss is very common in the rabbit and occurs mainly between the eleventh and fifteenth day of pregnancy (Brambell, 1948).

The possibility of embryo resportion and the effect that this might have on placental scars must be recognized in the evaluation of productivity data derived from placental scar counts.

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SUMMARY

If all embryos in the litter of a rat were resorbed at the same time, placental scars were usually formed at resorption sites when embryo death occurred on the eleventh day of pregnancy. Resorption after the eleventh day always resulted in scar formation while resorption prior to this never did.

If only part of the embryos in the litter were resorbed, embryo death on the seventh day or later resulted in scar formation at all resorption and term sites.

If some embryos resorbed between the eighth and eleventh day and the remainder after that, scars formed at all sites.

Placental scars formed similarly at resorption sites in four untreated animals and were indistingiushable from those found in the treated series.

The size and appearance of the scars of resorption were similar to term scars. No gross or microscopic criteria that would clearly distinguish between the two types of scars were found.

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A FIELD STUDY OF GROWTH IN *MICROTUS PENNSYLVANICUS*

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The genus *Microtus* is of great and widespread importance to agriculturalists and students of animal ecology because of its periodic fluctuations in numbers. That the often cited, extremely high reproductive potential indicated by Bailey (1924) for *M. pennsylvanicus* is seldom attained in nature and that deviations from the potential vary in different stages of population development was indicated by Hamilton (1937*a*). A detailed knowledge of the factors influencing reproductive rate, therefore, is essential to an understanding of population dynamics. One of these factors is growth rate. Growth rate not only affects the ontogeny of the individual, but its effects are transmitted directly to the population.

Laboratory studies of growth and development have been conducted by Ranson (1934) and others for *M. agrestis*, by Selle (1928) and Hatfield (1935) for *M. californicus*, by Bodenheimer (1941) for *M. guentheri*, by Morrison, *et al.* (1954) for *M. oeconomus*, by Cowan and Arsenault (1954) for *M. oregoni*, and by Hamilton (1937*b*, 1941) for *M. pennsylvanicus*. In general, these studies have indicated a rapid early growth averaging between 0.6 grams per day for the small *M. oregoni* to 1.0 grams per day for the large *M. californicus*. Female *Microtus* may begin to breed at an age of 3 to 4 weeks, and the male a week or two later. A period of relative sterility following puberty is recognized by Bodenheimer and by Cowan and Arsenault and is suggested for the male by Leslie and Ranson (1940). The young of *M. oregoni* born after late July do not attain puberty during the same season, and mice born late in the season grow slower than earlier captive litters.

Field studies on *M. pennsylvanicus* have been conducted by Hamilton (1937*b*, 1941) who indicates agreement with laboratory results. The only room for variation is suggested by the statement (1941), "Not all the marked mice which were recaptured showed such a rapid growth. . . . This mouse [a female initially weighing 19 grams on June 16] increased 13 grams in weight in 39 days." Males 60 days old should weigh 40 to 45 grams (1937*b*).

Observations of significant variation in the average size of adult males taken from different fields in the Ithaca, New York region during the summer of 1952 led the author to investigate the possible effects of soil fertility on the growth rate of this vole.

STUDY AREAS

Since the general areas where much of Hamilton's work was done were, by coincidence, all located on soils derived from calcareous lake-laid deposits, it was planned to compare growth rates of mice on a similar soil to those on a soil derived from acid sand-stone and shale till. The most recent soils map available at the beginning of the study (Howe, 1925) was used to select sites. Unfortunately, the high-lime area chosen in 1952 was unexpectedly reclaimed for surplus livestock in 1953. This concentrated work for that season on an area

near the East Hill Airport, five miles northeast of Ithaca. This area had been mapped as Volusia, a gley associate of strong Podzols. Recent revisions of the classification of New York soils by Dr. M. G. Cline have resulted in the remapping of the Ithaca region (Tompkins County) now in progress. The present incomplete map has been made available through the courtesy of Mr. Ned Giddings of the Soil Conservation Service, and indicates that the Airport field is now classified as Lyons, a Gray-brown Podzolic gley associate derived from till containing limestone.

Two of the 12 acres worked here had been planted to corn in 1951, and by 1954 had developed a fair stand of redtop (*Agrostis alba*) and Canada bluegrass (*Poa compressa*). Clovers (*Trifolium* spp.) were still abundant but had declined since 1952 and 1953. The rest of the area was mostly long-abandoned pasture, the composition of which varied with soil drainage, shade, and details of past management practices. Timothy (*Phleum pratense*), goldenrods (*Solidago* spp.), strawberry (*Fragaria* sp.), hawkweeds (*Hieracium* spp.) and cinquefoil (*Potentilla* sp.) dominated the drier areas; sedges (*Carex* spp.), native grasses (Gramineae), sensitive fern (*Onoclea sensibilis*), and woolgrass (*Scirpus cyparinus*) dominated the wetter areas. Willows (*Salix* spp.) and arrowwood (*Viburnum dentatum*) were common, but seldom dense enough to reduce herbaceous cover.

The area selected in 1954 (because no mouse sign could be located in more suitable fields) was a one-acre field on the farm of Dr. Lyman Fisher, five miles north of Ithaca. The soil type is Fulton (derived from lake-laid silts, shallow to bedrock). The vegetation was birdsfoot trefoil (*Lotus corniculatus*) and orchard grass (*Dactylus glomeratus*), with poverty grass (*Danthonia spicata*) in the drier spots and sedges (especially *C. granularis* and *C. vulpinoidea*) in the wetter. Chickory (*Cicorium intybus*), Queen Ann's lace (*Daucus carota*), and arrow-leaved aster (*A. saggitifolium*) were the most conspicuous of a variety of typical weeds.

Methods.—In 1953, various portions of the Airport field were live-trapped on five occasions between June and August, and again in late November. Traps, baited with rolled oats, were checked in the late morning and again just before dark. Mice were toe-clipped for identification and weighed to the nearest ½ gram on a pan balance by rolling them up in a light plastic bag. Most mice were weighed only once during each trapping period because of the time required to run 90 to 120 traps with no knowledge of how large the catch would be.

In 1954, the techniques of prebaiting and selective trapping permitted a good estimate of the catch, and time could be allowed to weigh all mice recaptured within a period. The Airport field was live-trapped in late June, July and August, and the Fisher field on the first weeks of July, August and September. Both areas were thoroughly snap-trapped in late September, 1954, and the Airport field was snap-trapped again in October.

RESULTS

Daily fluctuations of individual weights.—The time of capture, length of confinement, and reaction of the individual to the confinement situation affected

the weights of the captured animals. In general, mice recaptured at noon or in the evening following a morning capture had increased about two grams in weight. Many mice did not fluctuate beyond these narrow limits despite repeated captures in a short period. Others lost weight progressively, two grams per day being about average. Excessive losses of 15 to 20 per cent of "normal" body weight were not uncommon, and occasionally resulted in obvious weakening or death. One individual was left in a trap over night intentionally. H s weight went from 25.5 grams to 20.5 grams in 13 hours. This was the greatest relative loss observed in one day, and it is thus assumed that few mice entered the traps after sundown. The fact that "nervous" mice usually kicked the two to four grams of rolled oats out of the traps probably aggravated their situation. Female weight losses varied from 6 to 19 grams due to parturition.

It is obvious that the methods used involve an error much in excess of the mechanics of weighing. An estimate of the weight change of an individual between periods was made only after careful study of his records. In general, either the first morning or the first evening capture was compared to the corresponding figure for the preceding period, and it is assumed that the animals were in comparable trap-influenced condition. Individual fluctuations of less than 10 per cent between periods are probably not significant unless the majority of the population react similarly.

Summer growth of juveniles.—Hamilton (1941) has indicated that young meadow mice leave the nest to run about and feed beginning about the ninth day after birth at a weight of 11 grams. They are weaned beginning on the twelfth day at a weight of 14 grams. Bodenheimer (1949) gives 10 days and a weight of 7.5 grams as the minimal weight at which forced weaning is survived in *M. guentheri*. These generalizations would seem valid on the basis of the rarity with which mice weighing less than 10 grams are taken by snap-trapping, however, during the 1953 season, 14 mice weighing less than 10 grams each were live-trapped in the Airport area. Nine of these weighed between 5.5 and 7.5 grams, and five of this group (including the tiniest) were retrapped after a period of three weeks or more. Such good survival would not be expected of very abnormal young.

Recovery rates on juveniles is unfortunately low, and females are favored over males. At the Airport field, a total of eight mice (1M:7F) were recovered before reaching puberty in 1953, and eight more (4M:4F) in 1954. Only six (2M:4F) were recovered in the Fisher field, and four of these were the results of nine mice released on the area by E. J. Harrington on August 11, 1954. None of the females discussed here had been bred.

Little variation was observed in the growth rate of juvenile mice due to sex, field, or year. In 1953, during periods between June 25 and August 20, the rate of weight increase was 0.4 grams per day in the Airport field. In 1954, from July 27 to September 20, the average in the same area was 0.25 grams per day, with the fastest, a female, being 0.4 grams per day for a 27 day period. The rates on the Fisher field from August 11 to September 26 were between 0.2 and 0.5 grams per day. Recaptures over periods greater than three weeks may be

misleading, since a relatively rapid increase may be terminated sharply when a weight of 20 to 23 grams is reached and the subadult pelage is assumed in late summer.

Summer weights of subadult and adult males.—Hamilton (1941) has indicated that male *Microtus pennsylvanicus*, under natural conditions, may become sexually mature when five weeks old, at a weight of 25 grams or more. Five to 15 per cent of mice weighing 20 to 25 grams may be fecund (1937*b*), using size of the epididymis tubules, vesiculae, and testes as criteria. Christian (1950) has noted a 10.0 gram juvenile undergoing active spermatogenesis, although no spermatozoa were recorded from the epididymides. Such a condition is possibly not infrequent. Several live-trapped juveniles have been recorded in the present study as having enlarged and descended testes. These organs have apparently regressed later and withdrawn, leaving the individuals looking very much like females, with bare skin between the anus and penis.

The breeding condition of males cannot be determined with much certainty from external appearance. Jameson (1950) has recently re-emphasized the need for observing the accessory organs in determining fecundity. Observations in the present study suggest that the seminal vesicles of *M. pennsylvanicus* lag considerably behind the testes in development, and regress more readily. Since most of the animals whose growth rates were known were not dissected, few correlations are possible.

The greatest variation in growth rate occurs in the subadult and adult mice. At the Airport field in 1953, three 20 gram males increased at the rate of 0.4 grams per day from June 24 to July 26. At the same time, a 35-gram male increased 0.2 grams per day and a 42-gram male remained constant. From mid-July to mid-August, 11 of 18 mice uniformly distributed between the weights of 22 to 37 grams increased slightly (mostly 0.2 grams per day) and two lost slightly. In 1954, the males of this field were mostly in the 35 to 45 gram weight range during July. Equal numbers of 18 males lost and gained about 0.2 grams per day. A single mouse, weighing 25 grams on June 24, gained at the rate of 0.4 grams per day. On July 27, this mouse was two grams heavier than another male that had weighed 40 grams on June 23.

Between July 8 and August 7, 1954 on the Fisher field, all of nine mice ranging from 22.5 to 56 grams increased in weight. The fastest growing male recorded in this two-year study (0.6 grams per day), in going from 22.5 to 41 grams, outstripped by 1.5 and 5 grams two males that had originally outweighed him by 12.5 and 8.5 grams, respectively. During August, some 30 males from both fields remained about constant in weight, although 4 from the Airport field lost about 20 per cent. A general, slight upward trend in September may have been augmented by the replacement of live-trapping procedures with snap-traps.

Forty-four fecund and 50 non-fecund males were snap-trapped at the Airport field in late September. The weight range dividing fecund from immature was 27 to 31 grams. Four of six mice in this category were judged to be fecund. None of five mice in this weight range at the Fisher field were fecund. Of 29 males snap-trapped in the Airport field in October, 1954, three were judged to have been fecund earlier in the season. All three had severely regressed seminal vesicles.

From the evidence at hand it appears that males born after mid-June of 1953 and 1954 did not become fecund the same season.

Fall weights of males.—Seven marked males were recovered on November 27, 1953, at the Airport field. The smallest had increased, from 19 grams on August 13, to 20 grams. The largest had gone from 37 to 27 grams, and one from 29 to 22. The remaining four had lost somewhat less; amounts that could have been due to exposure in the traps, although they were well baited. Two of these mice were brought into the laboratory, where their weights increased from 20 to 23 and from 27 to 33 grams in two weeks. These individuals were examined by Dr. B. V. Travis of the Department of Entomology, Cornell University and found to be free of any gross infections of parasites. A new blood parasite was discovered in the smaller specimen and a subsequent study of this parasite will be reported elsewhere. Winter loss of weight in the wild has been reported for *M. agrestis* by Chitty (1952).

Weights of old males.—In 1954, six males marked in 1953 were recovered. Four had weighed between 20 and 27 grams in late August and were probably non-fecund then. In late June and late July, 1954, they weighed between 35 and 38 grams. One weighing 29 grams on August 12, 1953, (possibly fecund) weighed 39 grams when recaptured on June 19, 1954, and increased to only 40 grams in captivity. The weight of the sixth was estimated to be 20 grams on July 13, 1953. He weighed 38 grams on June 20, 1954, 35 grams on the morning of August 1, and 38 grams in the evening of the same day. It appears that none of the mice born after late June, 1953 surpassed 40 grams in weight in over a year of life in this field.

Females.—Except for fluctuations in weight due to pregnancy, there seems to be little difference in the physical development of the sexes. In contrast to the males, however, the onset of puberty in the females does not seem to be retarded by the summer season after a suitable weight is attained. Thus, at the Airport, of six juveniles weighing 12, 12, 13, 16, 18, and 20 grams in late June, 1954, all had conceived by either late July or August. Four juveniles weighing 8, 12, 13, and 19 grams in late July had all conceived by late August or September. In late August, one of two 19-gram females was in adult pelage. On September 18 it weighed 24.5 grams and was nursing four young. The second was in juvenile pelage, and, though the pelage had transformed by September 18, she weighed but 20.5 grams and had not been bred. A 10.5 gram mouse marked on August 27 had increased to 19.5 grams and was still in the juvenile pelage on September 18.

In September, 1954, 64 fecund and 19 non-fecund females were snap-trapped from this field. The range of weight dividing these two classes was 21 to 24 grams, with $\frac{5}{13}$ of this group being fecund. Only $\frac{1}{6}$ of this weight category was fecund in October. None of 12 females of this size taken in the Fisher field in September had been bred. Although the author has recorded a pregnant 18 gram juvenile *M. pennsylvanicus* in the Ithaca region, there is no reason to suspect that this is a general occurrence. The evidence of this study indicates that females born after mid-June probably do not reach puberty before an age of 6 weeks.

Only two females marked in 1953 were recovered in 1954. One was a 16-gram juvenile on July 10, and had increased to 27 grams by August 15. On June 23 of the following year she weighed 46 grams, but lost 9 grams 2 days later due to parturition. The second weighed 25 grams on August 21, 1953 and 38 grams when snap-trapped on September 17, 1954. She had several old placental scars but was not actively breeding. The weights of these females is comparable to that of the year-old males.

Most breeding females increased at the rate of about 0.5 grams per day—enough to produce a litter of four or five—and returned to the original weight. Some females producing their first litters may be exceptions to this generalization, but this is not readily determined in the field. The fastest growing individual recorded in this study was first taken on the Fisher field on July 8. She then weighed 26 grams. Twenty-nine days later she weighed 56 grams, and was giving birth when weighed. A day later she weighed 37 grams, and she weighed 39 grams 2 days after parturition.

Average weights of breeding males.—Of considerable interest are the frequency distributions of the weights of breeding males between years on the same areas and between areas. Table 1 gives the statistics for a series of mice snap-trapped on the Airport field in early September, 1952, and for the individuals live-trapped during the succeeding seasons on the Airport and Fisher fields. Maximum weight attained during the season is used for the individuals, with a two-gram class interval. Twenty-seven grams was picked as an arbitrary lower limit of fecundity. None of the distributions was badly skewed.

At the Airport, only two (3.4%) of the males exceeded 40 grams in 1953. In 1954, however, 30 (37%) passed this size and three reached 50 grams. The mice on the Fisher field were the largest observed in three years of study, during which 700–800 adult males from a dozen areas in the Ithaca region were handled. Is it a coincidence that 4 of the 20 adult males from this field exceeded the maximum weight (56 grams) observed in a large composite sample from other areas?

Hamilton (1937*b*) states, "A number of males were taken in excess of 60 grams, the largest weighing 71 grams." Such monstrous mice are not restricted to lush orchard and leguminous hay habitats on calcareous soils in the Ithaca region. Werner (1954) took many mice of this size in wooded habitats of the Thousand Island Region, New York during the summers of 1953 and 1954. The reason for the occurrence of these large mice is a problem.

Unless an extremely poor sample has been drawn, the breeding males of the 1953 season at the Airport field did not survive to the summer of 1954. The

TABLE 1.—*Weights of breeding male Microtus*

Locality and year	Mean and standard error (grams)	Maximum weight	Sample size
Airport, 1952	32.4 ± 1.7	40	9
Airport, 1953	33.5 ± 0.5	48	58
Airport, 1954	38.5 ± 0.6	52	81
Fisher, 1954	45.8 ± 2.2	62	20

non-breeders of 1953 weighed but 35 to 40 grams in 1954. The conclusion that must be reached is that the males exceeding 40 grams in weight in late June, 1954, were born on that area during the spring of the same year. Differences in weights between years may thus be due to the relative success of early spring breeding.

Of 11 populations (including two about one mile from the Airport field) sampled in the spring seasons of 1953 and 1954, none gave any indication of late winter breeding, and few mice conceived before April 1. This is in accord with Hamilton's (1937*a*) data for 1934 and 1935, but he has recorded mice breeding through the winter of 1935–6. There is considerable variation between localized populations of *Microtus* with regard to the time breeding commences, but it is most likely that few of the mice at the Airport were born before April 1. Hamilton (1937*b*) indicates that a weight of over 40 grams may be reached in 60 days, and that "mature" weight is reached in 12 weeks. It is thus possible for the large mice trapped at the Airport in June, 1954, to be young of the year.

If the above deduction is correct, we must search for the factors responsible for the great reduction in growth rate between spring and summer, and also the reasons why the mice of the Fisher field are so much larger than those of the Airport and other fields in the study. The ecological factors considered here are soils, weather and vegetation.

Soils.—Composite soil samples from each major vegetation type on the two fields were collected in early August, 1954. These were analysed by the Soil Testing Service of the New York State College of Agriculture at Cornell University under the direction of Dr. D. J. Lathwell. The findings are presented in Table 2. A tendency for calcium and phosphorus to accumulate in the depressions of the Airport field is apparent. Looking at the two areas as a whole, from

TABLE 2.—*Fertility status of soils in different areas of two fields*

Areas	pH	Pounds per acre				% Organic matter
		P	Ca	Mg	K	
Airport field						
Woods pasture						
Well drained	5.00	<1	2150	>150	85	>6.0
Poorly drained	5.90	2.5	6100	≫150	105	>6.0
Open pasture						
Well drained	5.75	<1	2450	>150	100	5.2
Imperfectly drained	6.30	<1	4280	≫150	70	4.8
Poorly drained	6.10	2.5	6250	≫150	80	>6.0
Old-field						
Imperfectly drained	5.85	<1	3180	>150	75	4.9
Poorly drained	6.70	1	5050	≫150	50	>6.0
Fisher field						
Poverty grass	6.55	<1	3320	>150	215	4.6
Trefoil and orchard grass	6.50	<1	3320	≫150	125	4.7
Sedge swale	6.20	<1	2650	≫150	130	4.4

the standpoint of agricultural production (disregarding drainage) Dr. Lathwell indicated that the *p*H and potash level in the Airport area were a little lower than desirable, while these characteristics were satisfactory at the Fisher field. No marked differences between the fertility status of the two fields is apparent.

Weather.—Climatological data of the U. S. Weather Bureau from the Cornell University station for the growing seasons of this study as well as for 1936—the year for which Hamilton (1941) gives individual growth records—are presented in Table 3. There are many deviations from the normal, to be sure, but none of these seems to be either unduly severe or favorable.

The 1953 season began with a dry June and the soil was not recharged until late winter. In 1954, ditches and shallow depressions held standing water in June. A deficit of rain in July and early August caused the shallow soil of the Fisher field to become powder-dry. It was impossible to collect soil samples with an auger here, and severe defoliation of the trefoil had occurred by early August. These conditions had no apparent effects on movements or reproduction of the mice. The Airport field was less affected by the short drought, and early fall rains left standing water in the low areas.

Part of the reason for the larger average size of the Fisher mice is the fact that they all increased in weight during July, while the Airport adults changed but little. A reasonable explanation for this is not apparent from weather effects.

Vegetation.—Probably no grazier would hesitate to select the one acre of lush trefoil and orchard grass over any two acres in the Airport area in late June. It is likely that this field also provides a superior forage for mice. However, so little is known about the food requirements of *Microtus* that no assump-

TABLE 3.—*Climatological data for Ithaca, New York*

	Total monthly precipitation				
	1936	1952	1953	1954	Normal mean
March	6.92	1.93	3.47	2.34	2.73
April	2.74	2.48	3.18	3.41	3.03
May	3.05	4.65	3.40	3.27	3.52
June	1.54	1.38	2.53	4.30	3.43
July	2.11	5.61	3.88	1.55	3.84
August	2.71	2.69	2.68	4.83	3.71
Sept.	1.66	2.50	1.83	1.91	3.31
	Average monthly temperatures				
	1936	1952	1953	1954	Normal mean
March	38.4	32.1	35.5	33.3	32.5
April	42.7	48.3	43.9	47.0	44.4
May	59.8	52.5	57.7	54.5	56.3
June	66.1	66.1	65.6	66.6	65.6
July	71.4	73.2	70.0	68.4	70.2
August	71.2	67.8	66.9	66.5	68.5
Sept.	63.2	62.3	62.0	60.7	60.7

tions based on a single sample are warranted. Research in the nutrition of laboratory and domestic animals is going on at a rapid pace and is producing many facts of potential value to students of wildlife. Application of these findings must be based on a detailed life history of the wild animals as well as normal physiological changes in plants due to season. Differences in plant parts and species fed on by field mice are obvious, yet the only attempt at a quantitative study of this important aspect has been done by Jameson (1947). He indicated that *M. ochrogaster* cuttings were composed of alfalfa to a greater extent than the relative abundance of this legume in the area studied.

Whether or not differences in plant species composition or in soil fertility between areas can influence the size of mice appreciably is questionable. Some acid, hill soils of the Arnot Forest area (17 miles southwest of Ithaca) are dominated by dense poverty grass, lichens, mosses, various weeds, and very sparse stands of timothy. A rich alluvial soil of the Inlet Valley (two miles west of Ithaca) supported a lush growth of blue grass (*Poa pratensis*), orchard grass, rushes (*Juncus effusus*), sedges and weeds. The differences in maximum sizes of snap-trapped mice between seasons and years within each area (1952 to 1954) were as great as the differences between areas at any given time; the largest male taken at the Arnot (56 grams) actually exceeded by three grams the largest from the Valley, in five semi-annual trapping periods. The Valley, however, supported a much denser population of mice, with less apparent effects on the vegetation.

DISCUSSION

Perhaps some of these data are suggestive of Chitty's (1952) hypothesis concerning mortality among *M. agrestis* following a "peak" year. If such relationships exist, they are obscure. The population at the Airport field has exhibited a relatively stable pattern during the short study period. No great differences in the size of the September populations are present, and the only conspicuous difference in the population structures is the high numbers of "large" breeders during the 1954 season. If it is possible to use these data to predict what the 1955 population would have been, the author is unaware of it.

The meagerness of the data presented here prevent any conclusions other than the obvious statement that variation in growth rate in *M. pennsylvanicus* between individuals, seasons, and areas exists. The extent of genetic fixation of this character is unknown and the influence of environmental factors is not obvious.

With a species that is known to vary greatly in population density, population structure, and reproductive rate on the same area in different seasons and between areas simultaneously, it cannot be expected that a single replicate will furnish sufficient proof to warrant a generalization concerning population dynamics; especially since no other worker has indicated the existence of any variation since the basic study of Hamilton was reported. It should be emphasized that the evidence here indicating markedly differential spring and summer growth is indirect and presumptive.

Additional studies on the factors causing variation in growth rate of *Microtus* are necessary. Differential growth rate can alter the reproductive potential of a population considerably, and relatively small effects on longevity may have important consequences to a population that approaches a 100 per cent annual turnover. The problem in the field is complex enough to provide opportunities for contributions from many students.

SUMMARY

Growth rate in *Microtus pennsylvanicus* was studied during the summer and fall of 1953 and summer of 1954 on a 12-acre area near Ithaca, New York. A one-acre field was also studied in 1954. Growth rates of juveniles varied from 0.2 to 0.5 grams per day during three to four week periods. Males born after mid-June did not reach puberty the same season. Females born after mid-June did not reach puberty before an age of 6 weeks. Loss of weight and failure to grow between August and late November, 1953, was recorded for males. Adult males did not survive from one summer to the next. Year-old males weighed between 35 and 40 grams. The occurrence of many males heavier than 40 grams in 1954 may have been due to successful early spring breeding and to a growth rate approximating that recorded by Hamilton. Differential growth and size of individuals is not readily attributed to soils, weather or forage composition.

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THE RELATION OF OXYGEN CONSUMPTION TO TEMPERATURE IN DESERT RODENTS

BY WILLIAM R. DAWSON

No information is available on the effects of temperature upon the oxygen consumption of any desert rodent, although the Schmidt-Nielsens (1950*a*) have made measurements on several species at 25° C. in the course of their extensive investigations of water metabolism (1952). Accordingly, this study dealing with the Merriam and Panamint kangaroo rats (*Dipodomys merriami* and *D. panamintinus*) and with the antelope ground squirrel (*Citellus leucurus*) was undertaken. It attempts to define the zones of metabolic thermal neutrality for these desert animals, to analyse their metabolic responses to ambient temperatures above and below thermal neutrality, and to compare the temperature regulation of the nocturnal kangaroo rats, which do not meet the most intense desert heat, with that of the diurnal ground squirrel, which periodically encounters high air temperatures and intense solar radiation.

This investigation was carried out during tenure of a U. S. Public Health Service Research Fellowship in the Department of Zoology, University of California, Los Angeles. I am grateful for the numerous courtesies extended by Dr. George A. Bartholomew in placing the facilities of his laboratory at my disposal.

Materials and Methods.—Twenty-five Merriam kangaroo rats, 15 Panamint kangaroo rats, and 12 antelope ground squirrels were used in this study. All were captured during June and July, 1953, at Lovejoy Buttes, Los Angeles County, California, a site located near the western edge of the Mojave Desert. They were housed in glass terraria during their stay in the laboratory. Each terrarium had a sand-covered floor and was provided with a 16 oz. bottle made of brown glass, which afforded the animals a place of retreat. Cotton was available for nesting material. The antelope ground squirrels and Panamint kangaroo rats were housed individually. The more sociable Merriam kangaroo rats were placed several to a terrarium.

Food consisting of sunflower seeds, millet seeds, lettuce, and water were avail-

able to the animals at all times, except when they were being studied. All three kinds of rodents were observed to drink occasionally. The animals maintained their weight and appeared in good condition throughout their stay in the laboratory.

Oxygen consumption was determined by means of a Beckman paramagnetic oxygen analyser equipped with a multiple sampling unit which permitted simultaneous study of as many as 5 animals. This assemblage was used in conjunction with a Brown recording potentiometer, so that it was possible to obtain essentially continuous records of oxygen consumption for each animal.

Kangaroo rats were housed individually during the experiments in glass cylinders 2½ in. in diameter and 15 in. in length. Each cylinder was equipped with a thermometer and with a wire-mesh platform on which the animal rested, and was sealed on either end with a rubber stopper fitted with a piece of glass tubing through which air could pass. Ground squirrels, on the other hand, were housed individually during the experiments in chambers consisting of one-gallon paint cans, the air-tight lids of which were fitted with ports for air and for a thermometer. While in these chambers, the squirrels rested upon wire-mesh platforms.

During the experiments, all the animal containers in use were connected to the multiple sampling unit of the oxygen analyser by separate air lines. Air that had been dried by passing through anhydrous $CaCl_2$ was metered through them at the rate of 600 cc. per minute. During the experiments fluctuation of temperatures to which the animals were exposed was prevented by keeping their containers in a large (24 cu. ft.) constant-temperature cabinet. With this arrangement, it was possible to control the ambient temperature within 0.2° C. of the desired level. Daylight fluorescent lights illuminated the constant-temperature cabinet, and this served to minimize activity by the nocturnal kangaroo rats in the glass cylinders. No illumination reached the diurnal ground squirrels in the gallon cans and the darkness served to keep their activity at a low level.

When animals selected for study on a particular day were removed from their terraria, their mouths and cheek pouches were emptied of any food they might contain to insure use of fasting individuals. Metabolic experiments were generally conducted over a period of 12 hours, and the lowest rate of oxygen consumption maintained for 40 minutes or more during the last four hours was taken as the standard rate for the particular ambient temperature to which the animals were being exposed. Data from experiments in which activity was detected were discarded.

Metabolic measurements were conducted at ambient temperatures ranging from 9° to 38° C. The oxygen and carbon dioxide levels in the animal containers remained above 19.5 and below 1.5 per cent, respectively, in every experiment. All gas volumes presented have been corrected to standard conditions of temperature and pressure (0° C. and 760 mm. Hg). Metabolic rates are expressed as cc. of oxygen consumed per gm. per hr. Data for kangaroo rats that became chilled at cool ambient temperatures (see below) are not included in Figure 1.

All body temperatures reported were measured rectally with a quick-register-

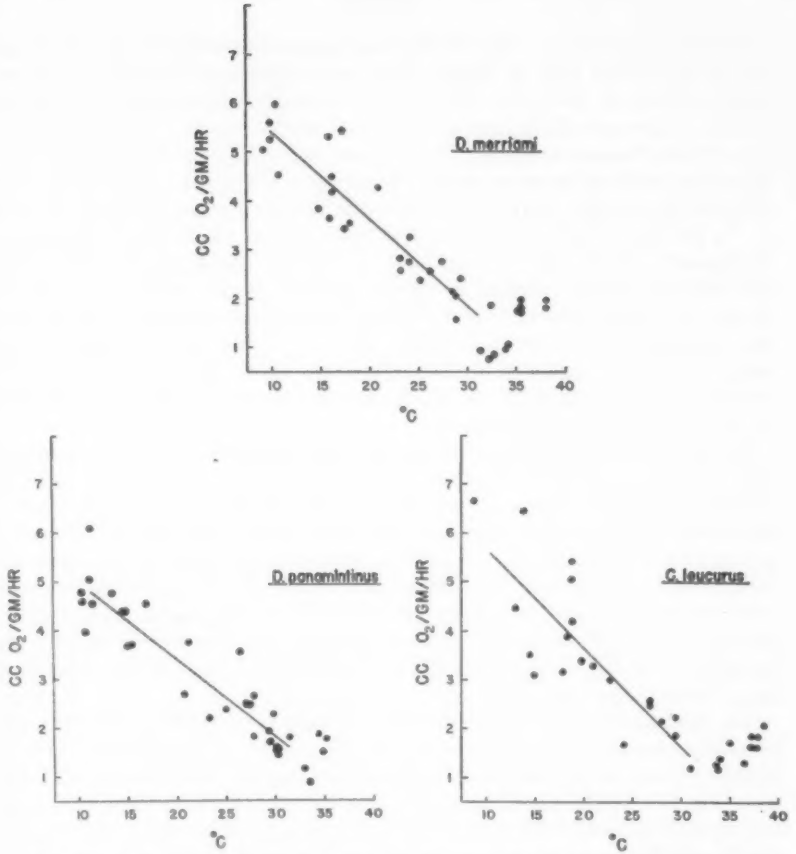

FIG. 1.—Effects of ambient temperature (degrees C.) upon oxygen consumption (cc./gm./hr.). No data are included for individuals of *Dipodomys* in which hypothermia was induced (See Table 1). Note the somewhat greater scatter of points for *Citellus leucurus* in comparison with the graphs for the kangaroo rats.

ing mercury thermometer designed for small animal work. Determinations were made principally at the end of the 12-hour metabolic experiments or of 3½-hour experiments expressly designed to induce heat stress in the animals by exposing them to an ambient temperature of 39° C. In the shorter experiments all three kinds of rodents were housed in small, wire-mesh cages instead of in the containers used for the metabolic experiments. Observations of body temperature in the absence of temperature stress were made upon individuals taken directly from the terraria described previously.

RESULTS

Dipodomys merriami.—The 25 Merriam kangaroo rats used in this investigation averaged 34.7 gms. in weight. Their zone of thermal neutrality lies somewhere between 31° and 34° C. (Fig. 1). In this range there is considerable scatter of points. Averaging them gives a value of 1.2 cc. O_2/gm./hr. for basal metabolic rate. Below thermal neutrality, metabolism appears to increase linearly with decreasing ambient temperature at the rate of 0.176 cc. O_2/gm./hr./° C. The equation for the least squares regression line fitted to the points below 31° C. is cc. O_2/gm./hr. $= 3.57 + (-0.176)(t - 20.14)$, where t is ambient temperature in degrees C. There is general agreement between the measurements reported by the Schmidt-Nielsens (1950*a*) at 25° C. for this species (mean rate 2.24 cc. O_2/gm./hr.; range 3.33–1.68) and the value for this temperature obtained from the regression line shown in Figure 1 (2.70 cc. O_2/gm./hr.). A small rise in oxygen consumption occurs with temperatures above thermal neutrality. At ambient temperatures above 34° C., the animals would frequently lie with their limbs extended, and appear lethargic.

The mean body temperature for the Merriam kangaroo rat at room temperature (23° C.) was 37.2° C. (range 35.6–38.1) based on nine determinations made during the daytime. Body temperature in this species is labile, and marked hypothermia was induced in several adult individuals representing both sexes, during 12-hour exposures to cool ambient temperatures (Table 1). All recovered their normal levels of body temperature after about two hours at room temperature, and they appeared to suffer no ill effects from being cooled. At body temperatures below 30° C. coordination was affected, and the animal with a body temperature of 22° C. was quite torpid. The metabolic rate of this individual was 1.39 cc. O_2/gm./hr.

The Merriam kangaroo rat shows little capacity for preventing hyperthermia at ambient temperatures above 34° C., as pointed out by the Schmidt-Nielsens (1952). Indeed, body temperature tends to vary directly with ambient temperature (Fig. 2) from the zone of thermal neutrality upward. This rodent has a good tolerance of elevated body temperatures, for individuals heated to 40° C. suffered no ill effects. Of the six animals exposed for 3½ hours or more to ambient

TABLE 1.—*Hypothermia in kangaroo rats**

Species	Weight Gms.	Ambient temperature °C.	Body temperature °C.
D. merriami	32.5	16.2	22.0
D. merriami	34.7	16.0	31.8
D. merriami	31.3	9.0	27.7
D. merriami	34.9	10.5	30.0
D. panamintinus	51.8	16.3	20.1
D. panamintinus	55.8	15.8	25.9
D. panamintinus	46.6	14.5	17.8

* Measured at the end of 12 hours' exposure.

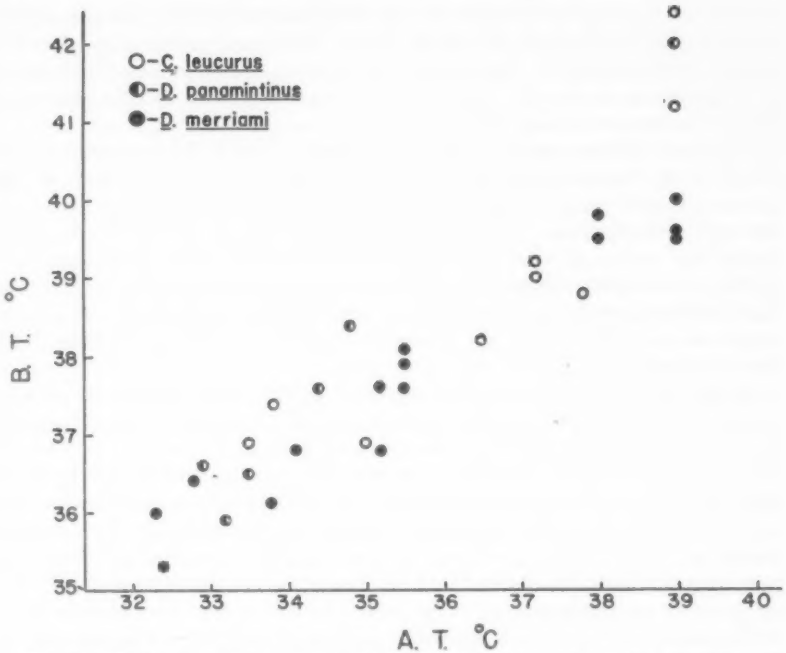

FIG. 2.—Rectal temperatures of three kinds of rodents at warm ambient temperatures. All measurements made at the end of 12 hours' exposure except those at 39° C., which were obtained at the end of 3½ hours. Values for individuals that died as a result of exposure are not included.

temperatures of 38° or 39° C., only one became fatally overheated. All the others succeeded in holding their body temperatures at 40° C. or below.

Dipodomys panamintinus.—The Panamint kangaroo rat is intermediate in size between the other two rodents studied, the 15 individuals used in this investigation averaging 56.9 gms. in weight. All were in adult pelage, but some of the smaller ones (45–55 gms.) were probably young of the year.

The zone of thermal neutrality for this species lies between 33° and 34° C. (Fig. 1). Extrapolation of the least squares regression line into this temperature interval indicates a value of 1.2 cc. O_2/gm./hr. for basal metabolism. Below 33° C. metabolism seems to increase linearly with decreasing ambient temperature at the rate of 0.158 cc. O_2/gm./hr./° C. The equation for the least squares regression line fitted to the points below 32° C. is cc. O_2/gm./hr. $= 3.17 + (-0.158)(t - 21.50)$, where t is ambient temperature in degrees C. A slight rise in metabolic rate is indicated above thermal neutrality. In experiments above 34° C., these rodents often would lie with their limbs extended and appear quite lethargic.

The mean body temperature at room temperature (23° C.) for this species was

36.9° C. (range 36.2–37.3) based on 7 measurements made during the day. Three animals exhibited hypothermia in the course of 12-hour exposures to approximately 15.5° C. (Table 1). All recovered after a couple of hours at room temperature. In other experiments, these same individuals were successful in regulating their body temperatures at ambient temperatures as low as 9° C.

The direct relation between body temperature and ambient temperature above 32° C. in the Panamint kangaroo rat is indicated in Figure 2. Animals of this species tolerated ambient temperatures as high as 35° C. for 12 hours. However, the only individual used in a metabolism experiment at 38° C. became overheated and died after four hours' exposure. Two out of three individuals subjected to an ambient temperature of 39° C. in an experiment scheduled for 3½ hours died at body temperatures of 45.2° and 44.3° C., respectively, after three hours' exposure. The surviving animal had a body temperature of 42.0° C. at the end of the experiment.

Citellus leucurus.—The 12 antelope ground squirrels were the largest animals used in this study, averaging 79.2 gms. in weight. Some of them were young of the year. All of them were highly excitable animals that did not seem to adapt so well to the experimental conditions to which they were exposed as did the more tractable kangaroo rats. This undoubtedly contributed to the considerable scatter evident when the data are plotted against temperature (Fig. 1). Thermal neutrality in this species extends from about 31° to 34° C., and the basal metabolic rate is 1.3 cc. O_2/gm./hr. Below 31° C. metabolism appears to increase in a linear manner with decreasing ambient temperature at the rate of 0.202 cc. O_2/gm./hr./° C. The equation for the least squares regression line fitted to the points below thermal neutrality is cc. O_2/gm./hr. $= 3.49 + (-0.202)(t - 20.84)$, where t is temperature in degrees C. With ambient temperatures above 34° C., metabolic rate increases slightly in the antelope ground squirrel.

The mean body temperature for this species at room temperature (23° C.) is 37.2° C. (range 35.6–38.1), based on nine measurements made during the daytime. All ground squirrels exposed for 12 hours to cool ambient temperatures (9°–16° C.) held their body temperatures at or very near the level maintained at 23° C., judging by their alertness and coordination at the end of the metabolism experiments.

Animals exposed to ambient temperatures at or above thermal neutrality for several hours exhibited elevated body temperatures comparable to those noted in Merriam kangaroo rats under the same conditions (Fig. 2). Their tolerance of hyperthermia was good; body temperatures up to 42.4° C. induced no apparent ill effect. This is equivalent to the tolerance noted by Johnson (1928) in the thirteen-lined ground squirrel (*C. tridecemlineatus*). One antelope ground squirrel that became heated to 43.1° C. when exposed for 3½ hours to an ambient temperature of 39° C. died shortly after it was removed to a cooler environment. It had salivated profusely during the terminal stage of its exposure, apparently as a means of emergency heat regulation of the type described for heated kangaroo rats by the Schmidt-Nielsens (1952), and for the mouse, rat, and guinea pig by Herrington (1940).

The ease with which hyperthermia can be induced in the antelope ground squirrel suggests that this animal does not possess the capacity to remain active for long periods of time in the sun during the middle of summer days. This is further borne out by the fact that a captive individual that was exposed to direct solar radiation on a clear July day died of overheating within an hour and a half. The intense heat (air temperature 38° C.; black bulb temperature over 50° C.) combined with its efforts to escape created a caloric load with which it could not cope.

DISCUSSION

It is well known that basal metabolism of placental mammals tends to vary with the 0.73 power of body weight at the interspecific level (Brody, 1945). Furthermore it has been shown by Morrison (1948) that this relation pertains in rodents. Thus, it is of interest to compare observed basal values for the desert rodents with the values predicted for animals of their weights. These theoretical values have been computed with the equation: basal metabolism (cc. O_2/gm./hr.) $= kW^{-0.27}$, where k is a constant and W is body weight in grams. (This is the weight-specific counterpart of the equation given by Brody for the familiar "mouse to elephant curve"). The observed basal value for the Merriam kangaroo rat (1.2 cc. O_2/gm./hr.) diverges from the predicted value (1.6 cc. O_2/gm./hr.) by 25 per cent. Better agreement is evident in the values for the Panamint kangaroo rat (1.2 cc. O_2/gm./hr. observed vs. 1.3 predicted) and for the antelope ground squirrel (1.3 cc. O_2/gm./hr. observed vs. 1.2 predicted).

The conformance of the antelope ground squirrel to the "mouse to elephant curve," despite a probable capacity for hibernation, is in agreement with the findings of Scholander *et al.* (1950*a*) on the arctic ground squirrel (*C. parryi*), a species known to hibernate. In contrast, the marmot (*Marmota monax*), another hibernating rodent, is known in the non-hibernating state to have an unusually low basal metabolic rate for an animal of its size (Benedict, 1938).

The metabolic responses to temperature of all three desert rodents compare closely with those observed in the laboratory mouse, rat, and guinea pig (Herrington, 1940). All have narrow zones of thermal neutrality. The limits of the zones in the desert rodents are a few degrees higher than in the laboratory rat. However, they agree closely with those for the mouse and guinea pig.

Considerable difference exists between the antelope ground squirrel and the much larger (ca. 600 gms.) arctic ground squirrel (*C. parryi*) in width of the zone of thermal neutrality (Scholander, *et al.*, 1950*b*). The zone of the desert form is only about 3° C. wide, whereas that of the arctic form is approximately 25° C. wide, with the lower limit at about 7° C. An associated difference in heat tolerance is apparent, for Sullivan and Mullen (1954) found that a condition resembling heat prostration was induced in arctic ground squirrels exposed to ambient temperatures between 25° and 30° C. Antelope ground squirrels easily tolerate such temperatures.

Below thermal neutrality, the oxygen consumption of both kangaroo rats increases with decreasing ambient temperature at rates comparable to those re-

ported by Morrison and Ryser (1951*a*) for Wisconsin rodents of similar size (Table 2). This seems noteworthy, for both these desert rodents were probably adapted to the summer temperature conditions prevailing in their particular environments since they were captured during the latter parts of June and July. Although these conditions are not the most extreme the desert has to offer, they are undoubtedly warmer than those to which the Wisconsin rodents were acclimated.

The elevated rates of metabolism of fasting kangaroo rats at cool temperatures generally could be maintained over 12 hours and were sufficient to hold body temperature near the level usually maintained in the absence of temperature stress. In some instances, however, these rates were not maintained and hypothermia ensued (Table 1). This probably resulted from an inability of these animals in a post-absorptive state to mobilize their fat reserves rapidly enough to permit adequate heat production. Howard (1951) has shown that small rodents, including kangaroo rats, are successful in regulating temperature in the cold during winter only if food is continuously available. It is of interest that chilling occurred only in the smaller (56 gms. or less) Panamint kangaroo rats, whereas no such correlation with weight is apparent in the Merriam kangaroo rats. Normally, maintenance of homeothermy by animals of these species at low ambient temperatures is undoubtedly facilitated by the shelter afforded by their burrows, where it is warmer than above ground—Vorhies (1945) observed that the burrows of banner-tailed kangaroo rats (*D. spectabilis*) remained at least 8° C. warmer than the air at ground level, throughout winter nights in Arizona.

The variation among the Merriam and Panamint kangaroo rats in temperature regulation in cool environments is reminiscent of that observed in the deer mouse (*Peromyscus leucopus*) by Morrison and Ryser (1951*b*). Some of their animals became cooled as much as 15° C. when exposed for an hour to 0° C., whereas others maintained a normal level of body temperature under the same conditions. The tolerance of the deer mouse to low body temperatures seems comparable to that observed in the kangaroo rats. In contrast, the observations of Kendeigh (1945) suggest that another species of *Peromyscus*, the white-footed mouse (*P. maniculatus*), is somewhat less tolerant of hypothermia than these desert rodents.

Below thermal neutrality the increase of oxygen consumption with decreasing ambient temperature is more rapid in the antelope ground squirrel than in either the kangaroo rats or Morrison and Ryser's larger Wisconsin rodents (Table 2). This could be because the coarse summer pelage of the squirrel affords it less insulation than the finer pelage of these other animals. Morrison and Ryser (1951*a*) found the metabolic response of another, larger ground squirrel (*C. [tridecemlineatus?]*) below thermal neutrality to be closely comparable to that of the white rat, an animal of similar size.

It seems likely that the Merriam kangaroo rat actually encounters heat stress in nature, judging by microclimatological observations of its shallow burrows (Schmidt-Nielsen and Schmidt-Nielsen, 1950*b*), which indicate that temperatures in them regularly approach the upper limit of its heat tolerance, during summer.

TABLE 2.—*Metabolic responses of various rodents to ambient temperatures below thermal neutrality*

Rodent	Body weight Gms.	Increase in metabolism per degree C. lowering of ambient temperature Cc. O_2/gm./hr.
*Zapus**	25	0.202
D. merriami†	35	0.176
*Eutamias**	47	0.166
*Microtus**	51	0.139
D. panamintinus†	58	0.158
*Glaucomys**	75	0.090
C. leucurus†	79	0.202

* Morrison and Ryser (1951*a*).
† This study.

Under such conditions, this rodent undoubtedly cannot prevent body temperature from rising, as shown by the observations of the Schmidt-Nielsens (1952) and myself (Fig. 2). Consequently, tolerance of elevated body temperatures is an important physiological attribute of this species, despite its evasion of the most intense desert heat as a result of burrowing.

The Merriam kangaroo rat's ability to occupy its characteristically shallow burrows may involve greater heat resistance than is possessed by other kinds of kangaroo rats. Observations reported here on body temperature and survival at 38° and 39° C., while not conclusive, are certainly suggestive that it surpasses the Panamint kangaroo rat in ability to cope with heat stress. Furthermore, observations of kangaroo rats caged above ground during daylight hours in the Nevada desert (R. G. Lindberg, pers. comm.) indicate that *D. merriami* is more heat resistant than *D. deserti*, *D. microps*, or *D. ordi*. Additional comparisons of the heat resistance of kangaroo rats should be undertaken to analyse this situation more fully.

It is of considerable interest that the diurnal antelope ground squirrel has about the same capacity for temperature regulation at warm ambient temperatures as the smaller and nocturnal Merriam kangaroo rat (Fig. 2). The prevention of overheating by this squirrel during the middle of hot summer days appears dependent upon its remaining relatively inactive in the shelter of bushes, rocks, or its burrow. Significantly, Johnson *et al.* (1948) observed antelope ground squirrels in the Providence Mountains area of California to be active between dawn and 10:00 AM and relatively inactive for the rest of the day in summer, whereas they were most active during the middle of the day in winter. It seems likely that this animal's demonstrated tolerance of elevated body temperatures is of critical importance in permitting it to remain above ground at all during the hottest part of summer days.

It is significant from the standpoint of comparative physiology that desert animals of the kinds studied here actually possess very limited powers of temperature regulation, despite their living in an environment characterized by wide extremes of temperature. In every case, these animals make the most of the

capacities they do possess by suitable behavior patterns which tend to reduce temperature stress. As the Schmidt-Nielsens (1952) have suggested, such behavioral patterns and a lack of dependence on evaporative cooling for heat regulation are factors of critical importance in permitting small rodents to contend successfully with the other great challenge of desert existence, aridity.

SUMMARY

The effects of ambient temperatures from 9° to 38° C. on the oxygen consumption of the Merriam kangaroo rat (*Dipodomys merriami*), the Panamint kangaroo rat (*D. panamintinus*), and the antelope ground squirrel (*Citellus leucurus*) are analysed. The zones of thermal neutrality for all three species are 3° C. or less in width, and oxygen consumption increases markedly with decreasing ambient temperature below 31° C. None of these desert rodents has an extensive capacity for temperature regulation in warm environments, and body temperature varies directly with ambient temperature above 32° C. Good tolerance of elevated body temperature was observed in all three species. In both species of kangaroo rats, some individuals were unable to maintain body temperature at normal levels when exposed without food for 12 hours to cool (9°–16° C.) ambient temperatures. The importance of behavior in the temperature regulation of both the diurnal squirrel and the nocturnal kangaroo rats under natural conditions is discussed.

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VITAMIN EXCRETION BY DEER

BY A. E. TEERI, E. POMERANTZ, N. F. COLOVOS, AND H. A. KEENER

It is well established that diet influences the intestinal flora of certain species of animals and that certain vitamins of the B complex are synthesized by microorganisms in the digestive tract (Gall, Illingworth, Cowgill and Fenton, 1948; Gall, Fenton and Cowgill, 1948). This synthetic activity is of particular importance to ruminants, and those that have been studied include cows (Johnson, *et al.*, 1947; Pounden and Hibbs, 1948*a*, *b*; Hibbs, and Pounden, 1948; Teeri, *et al.*, 1951*a*, *b*, 1953) and sheep (Pearson, *et al.*, 1953). Another ruminant for which such synthetic activity might be especially important because of its sometimes rather limited diet, and one for which nothing in this connection has been reported previously, is the deer (*Odocoileus*). Such information is presented in this report in the form of fecal and urinary excretion values for nicotinic acid, riboflavin, thiamine and vitamin B_{12}.

Three male deer (*Odocoileus virginianus*) provided by the New Hampshire Fish and Game Department were used in this study. All were between ten and twelve months of age, and weighed as follows: No. 1, 65 lbs.; No. 2, 94 lbs.; and No. 3, 82 lbs. The animals were maintained in metabolism stalls, thus making possible the regular collection of 24-hr. urine and feces samples. Daily aliquots were preserved, by freezing for the feces and by refrigeration at a temperature just above freezing for the urine, and at the end of the collection period the successive aliquots were pooled for analysis. The lengths of the collection periods were eight days for Nos. 1 and 3 and three days for No. 2. In all cases a preliminary feeding period of approximately two weeks served to adjust the deer to their ration, which consisted solely of balsam fir (*Abies balsamea*) and water.

For comparative purposes a similar experiment was carried out with a group of four young dairy cows consisting of two Ayrshires, Nos. 1 and 4, and two Guernseys, Nos. 2 and 3. These animals were all between one and two years of age. Their ration consisted of hay and water, and the lengths of the collection periods were from 14 to 17 days.

All vitamin analyses were made by microbiological procedures. Nicotinic acid, riboflavin and thiamine were determined as previously cited (Teeri, *et al.*, 1950) by use of *Lactobacillus arabinosus* (A.T.C.C. no. 8014), *Lactobacillus casei* (no.

TABLE 1.—*Vitamin content of the rations as fed (Micrograms per gram)*

Ration	Nicotinic acid	Riboflavin	Thiamine	Vitamin B_{12}
Hay (fed to dairy cows)	24.0	4.5	1.75	0.0110
Fir (fed to deer)	18.0	1.9	0.067	0.0004

7469) and *Lactobacillus fermenti* (no. 9338), respectively. Vitamin B_{12} determinations were carried out according to the U.S.P. procedure involving use of *Lactobacillus leichmannii* (no. 7830).

The vitamin contents of the rations, as fed, are presented in Table 1.

RESULTS AND DISCUSSIONS

Table 2 presents the average daily excretions of nicotinic acid, riboflavin, thiamine and vitamin B_{12} by the deer when fed the fir ration. For purposes of comparison with another ruminant, Table 3 presents similar data obtained with young dairy cows when fed a hay ration.

TABLE 2.—*Vitamin excretions by deer on fir ration**

Deer number	Feces	Urine	Total
	Nicotinic acid (mg./day)		
1	7.2	11.1	18.3
2	26.2	13.4	39.6
3	9.3	3.8	13.1
Average	14.2	9.4	23.6
	Riboflavin (mg./day)		
1	0.8	2.3	3.1
2	2.9	2.2	5.1
3	1.2	1.0	2.2
Average	1.6	1.8	3.4
	Thiamine (mg./day)		
1	0.33	0.37	0.70
2	0.62	0.43	1.05
3	0.34	0.08	0.42
Average	0.43	0.29	0.72
	Vitamin B_{12} (micrograms/day)		
1	16.4	1.6	18.0
2	68.1	3.4	71.5
3	15.3	0.6	15.9
Average	33.3	1.9	35.2

* Average daily vitamin intakes were: nicotinic acid, 22.2 mg.; riboflavin, 2.34 mg.; thiamine, 0.082 mg.; Vitamin B_{12}, 0.500 micrograms.

TABLE 3.—*Vitamin excretions by cows on hay ration**

Cow number	Feces	Urine	Total
	Nicotinic acid (mg./day)		
1	25.7	10.5	36.2
2	33.4	7.9	41.3
3	28.7	12.0	40.7
4	27.6	9.8	37.4
Average	28.8	10.1	38.9
	Riboflavin (mg./day)		
1	7.3	3.3	10.6
2	8.2	2.4	10.6
3	8.2	4.6	12.8
4	6.1	2.9	9.0
Average	7.4	3.3	10.7
	Thiamine (mg./day)		
1	4.7	3.3	8.0
2	6.7	3.5	10.2
3	5.7	5.1	10.8
4	6.9	4.3	11.2
Average	6.0	4.1	10.1
	Vitamin B_{12} (micrograms/day)		
1	118	0.19	118.2
2	100	0.37	100.4
3	82	0.80	82.8
4	167	0.39	167.4
Average	116.8	0.44	117.2

* Average daily vitamin intakes were: Nicotinic acid, 120.0 mg.; riboflavin, 22.5 mg.; thiamine, 8.75 mg.; vitamin B_{12}, 55.0 micrograms.

The average excretion of nicotinic acid by the deer was approximately the same as the intake, indicating no great amount of rumen synthesis of this vitamin. That some does occur is seen from the fact that in the case of one of the deer, No. 2, the excretion of nicotinic acid definitely exceeded the intake. From these results it would seem that while rumen or intestinal synthesis of nicotinic acid does occur, it probably is not of very great importance in the nutrition of the deer both because of the widespread natural occurrence of this vitamin, and also because of tissue synthesis (Johnson, *et al.*, 1947). This conclusion is in agreement with previous findings with dairy cows (Teeri, *et al.*, 1950, 1951*a*, *b*).

The data with respect to riboflavin indicate a small amount of rumen synthesis of this vitamin in the deer but not the dairy cows. It has previously been shown that in some instances riboflavin is synthesized in the rumen of dairy cows (Teeri, *et al.*, 1951*b*). It appears, therefore, that riboflavin synthesis is characteristic of

ruminants in general, but that it is of great importance only when the ration does not supply enough of the vitamin.

Rumen synthesis of thiamine occurred in both deer and dairy cows. This synthesis was much more extensive in the case of the deer where the average excretions exceeded intakes by from five to twelve times. It is evident that the synthetic activity of the rumen microorganisms is of particular importance when the thiamine content of the ration is low.

Vitamin B_{12} also was synthesized in the rumen of both the deer and the dairy cows. As with thiamine, B_{12} synthesis was much more extensive in the deer, where the average excretions exceeded intakes by from 31 to 143 times. The extent of this synthesis is quite similar to that which has been reported for sheep (Pearson, *et al.*, 1953). Another similarity is the fact that by far the greatest portion of the excreted B_{12} was found in the feces, indicating either poor absorption of this vitamin or that much of it was metabolized to other compounds.

The extremely small amount of vitamin B_{12} in the balsam fir, which often is an important part of a deer's ration, suggests the great importance, in the nutrition of the deer, of the rumen synthesis of this vitamin. This also indicates the indispensability of cobalt in the ration, since B_{12} cannot be synthesized in its absence.

SUMMARY

The synthesis of nicotinic acid, thiamine, riboflavin and vitamin B_{12} in the rumen of the deer has been indicated by quantitative measurement of the urinary and fecal excretions of these vitamins when the deer were fed a ration consisting of balsam fir. While the synthesis of nicotinic acid and riboflavin was slight, that of thiamine, and particularly of vitamin B_{12}, was more extensive.

Vitamin synthesis by rumen microorganisms is an activity common to all ruminants. This fact is of particular importance to deer, which often may be subjected to a rather limited type of diet.

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Department of Agricultural and Biological Chemistry and Department of Dairy Husbandry, Agricultural Experiment Station, University of New Hampshire, Durham. Received April 2, 1955.

A NEW FOUR-TOED ANTEATER FROM MEXICO

BY WILLIAM B. DAVIS

In the course of a biological reconnaissance of the Mexican state of Guerrero now under way in cooperation with the Mexican Department of Game, several forms that appear to be new to science have been collected by our field parties. One of them is a four-toed anteater, *Tamandua tetradactyla*, which heretofore has not been recorded from western Mexico north of the Isthmus of Tehuantepec. Two of the specimens we have are females, as judged by the presence of pectoral mammae. These specimens were shot at night by a local hunter in a deep canyon supporting vegetation with tropical affinities east of the village of Acahuizotla, about 35 kilometers south of Chilpancingo, on the Pacific slope of the Sierra Madre del Sur. The third, a skin only, was taken a few years ago near Chapalapa and partially mounted by a local hunter. This part of Mexico is a region of high endemism as attested by the large number of kinds of birds, reptiles, amphibians, and mammals that are peculiar to the area. The occurrence, therefore, of a population of *Tamandua* in southern Guerrero that differs from the east-Mexican anteaters is not surprising.

I am indebted to Mr. George G. Goodwin for the privilege of examining certain specimens of *Tamandua t. mexicana* from Veracruz, for records of other specimens in the American Museum of Natural History, and for making comparisons and pertinent comments on the first specimen we acquired in 1953. Also

I wish to acknowledge the assistance of the following persons who provided locality records of four-toed anteaters in various American museums: Miss Frances L. Burnett, Museum of Comparative Zoology (M.C.Z.); Dr. Keith Kelson, formerly at the University of Kansas Museum of Natural History (U.K.M.N.H.); Miss Viola S. Schantz, Biological Surveys Collection, U. S. Fish and Wildlife Service (B.S.); Mr. Colin C. Sanborn, Chicago Museum of Natural History (C.M.N.H.); and Dr. George Lowery, Louisiana State University Museum of Zoology (L.S.U.M.Z.).

Tamandua tetradactyla hesperia, subsp. nov.

Holotype.—Adult female, Texas Cooperative Wildlife Collection, No. 5322, collected by Joaquin Villanueva near Acahuizotla, 2800 feet elevation, Guerrero, Mexico, in April, 1953. Paratypes: TCWC No. 5610, female, from Acahuizotla, February 20, 1955; TCWC No. 5611, skin only, from Chapalapa.

Diagnosis.—A member of the species *T. tetradactyla* with relatively short, narrow rostrum (length from lacrimal foramen to tip of nasal, 52.4 and 56.6 mm.); pterygoid section of auditory bullae relatively large and encroaching on the foramen ovale; foramen magnum large (13.0 mm. x 13 mm.); frontals distinctly depressed; a distinct interpterygoid space 1 mm. wide extending forward to a plane through the foramina ovale; mandibular ramus short (about 100 mm.).

Measurements (in millimeters).—Type first, followed by paratype (No. 5610) in parentheses: Total length, 1145 (1015); tail, 568 (485); ear 28 (28) (from tanned skins). Occipitonasal length, 118 (120.2); length of nasals, 38.5 (43.1); breadth of braincase, 41.8 (40.3); width across rostrum at anterior edge of orbit, 30 (34.4); width of constricted part of rostrum, 17 (20); least interorbital breadth, 24 (25); length of rostrum from lacrimal foramen to tip of nasals, 52.4 (56.5); jugal, 16.5 x 5.5 (absent in paratype); length of mandibular ramus, 98 (102). Weight of paratype No. 5610, 3 kilos.

Comparisons.—Externally similar to *T. t. mexicana* from the eastern coast of Mexico, but differs in actually and relatively shorter nasals (length 38.5–43.1) as opposed to 51; foramen magnum noticeably larger (13 mm. in both vertical and horizontal diameters); frontal region distinctly depressed rather than not; interpterygoid space nearly twice as long; pterygoid section of auditory bullae more inflated, crowding the foramen ovale and forming the posterior margin of that opening, rather than separated from foramen ovale; mandibular ramus much shorter (98–102 as opposed to 113 or more). Differs from *T. t. chiriquensis*, based upon J. A. Allen's description (Bul. Amer. Mus. Nat. Hist., 20 (33): 395–396, 1904) as follows: rump and basal portion of tail whitish, not blackish; rostrum narrower (17–20, as opposed to 22.8); nasals much shorter (38.5–43 as opposed to 55).

Remarks.—Among named forms of the four-toed anteater, the specimens from Guerrero appears to be most closely related to *mexicana*. It has the same color pattern, but differs in cranial details as recorded above.

Little information concerning the distribution of *Tamandua tetradactyla* in

Mexico is available in the literature. Consequently, the following records, based upon specimens in American museums, may be helpful in outlining the distribution of this species in Mexico. No attempt has been made to assign specimens to subspecies because I have not been able to examine all the specimens. *Chiapas:* Hueheután (B.S.). *Campeche:* Apazote (B.S.), La Tuxpena (B.S.). *Quintana Roo:* El Mexo (C.M.N.H.), Xcopen (M.C.Z.). *Veracruz:* 37 km. E. and 7 km. S. Jesus Carranza (U.K.M.N.H.), Mirador (B.S.), Achotal (C.M.N.H.), Pasa Nueva (A.M.N.H.). *Oaxaca:* Huilotepec (B.S.), Reforma (C.M.N.H.), Santa Ifigenia (B.S.), Las Cuevas (A.M.N.H.), Juchitán (A.M.N.H.), Tapana (M.C.Z). *Guerrero:* Acahuizotla (T.C.W.C.), Chapalapa (T.C.W.C.). *San Luis Potosí:* 5 km. S. Tamazunchale (L.S.U.M.Z.).

Department of Wildlife Management, Texas A. and M. College, College Station, Texas. *Received August 28, 1955.*

GENERAL NOTES

OPOSSUM TAKING REFUGE UNDER WATER

J. Kenneth Doutt reported recently (Jour. Mamm., 35: 581–583, 1954) on his observations of the swimming ability and behavior of the Virginia opossum, *Didelphis marsupialis virginiana*, in a tank and when placed in a pond. Both opossums that he placed in a tank of water dived beneath the surface at once and swam a few feet under water before surfacing. The animals' ease at swimming and readiness to dive, apparently in seeking escape, led Mr. Doutt to speculate that it may do this naturally in the field to escape its predators. The following incident transcribed from my field notes of the behavior of a free, wild opossum of this same form may be taken to substantiate Mr. Doutt's supposition.

At 9:00 PM, October 12, 1953, where the Ingraham Highway (Florida Route 27) crosses Pine Island a mile inside the eastern entrance to the Everglades National Park in south Florida, Willard E. Dilley, L. Neil Bell, and the writer observed a small opossum cross the road in our headlights. Stopping, we walked up to the creature on the road shoulder. Upon our close approach, it turned toward the canal-like roadside ditch, which was full of clear water above its actual edges, and entered it confidently, starting to swim away. The ditch here was about three or four feet deep and five or six feet wide, its sides descending sheer to a squared off bottom. Stepping forward quickly, one of us reached for the opossum's tail. At this the animal plunged its head down and dived straight down, disappearing into the rank aquatic vegetation at once. We watched closely with our flashlights, and the opossum did not become visible until it had swum fifteen feet beneath the submerged vegetation. It swam five feet farther still before surfacing to breathe. It continued five or six feet farther on the surface and then stopped with its head half hidden under some vegetation on the near side of the ditch.

Mr. Dilley approached it softly and caught it by the nape. As he held it up, we noted lumps in the pouch area. The mouth of the pouch was drawn so nearly shut that it did not easily admit my finger which was inserted to draw the pouch open for inspection. There were four young in it, all about the size of adult cotton mice (*Peromyscus gossypinus*). Unfortunately we did not observe whether the interior of the pouch was dry when we opened it. Hartman (POSSUMS, 1952) says that the mother opossum can close her pouch tightly enough to prevent the entry of water when she swims. Upon being released, our opossum took to the water once more, swimming away from us on the surface, and as we departed, we saw it turn back to the near shore again.—JOSEPH CURTIS MOORE, *Everglades National Park, Homestead, Florida.* *Received December 18, 1954.*

RARE SHREWS FROM UTAH AND WYOMING

The collection of mammals in the Museum of Zoology, University of Utah, contains representatives of two rare species of shrews of the genus *Sorex*. These specimens were obtained from Utah and Wyoming during 1952–1954. Because of their rarity, and inasmuch as their localities of capture extend the known areas of occurrence, we considered it worthwhile to report upon them. This research was financed in part by a grant from the National Science Foundation.

Sorex merriami leucogenys Osgood.—Osgood (Proc. Biol. Soc. Washington, 22: 52, April 17, 1909), on the basis of a single specimen, named this subspecies as *Sorex leucogenys*. The type locality is "Mouth of the canyon of Beaver River, about 3 miles east of Beaver, Beaver County, Utah." Despite intensive collecting, no additional specimens were reported for 26 years, when Benson (Univ. California Publs. Zool., 40: 439–455, December 31, 1935), reported upon five specimens from War God Spring, Navajo Mountain, San Juan County, Utah. Since 1935, although even more intensive collecting of mammals has been effected throughout the state of Utah, no additional specimens have been reported. Two specimens, males (skins, skulls and skeletons), numbers 10896 and 10897, were obtained on July 27 and 28, 1954, at Gooseberry Ranger Station, Elk Ridge, 8,560 feet, San Juan County, Utah. At the time Benson and Bond (Jour. Mamm., 20: 348–351, August 14, 1939), synonymized *Sorex leucogenys* and *Sorex merriami*, there were only ten known specimens of *Sorex merriami leucogenys*. The two specimens from southeastern Utah, here reported, increase the number of known specimens to twelve. Moreover, these two specimens extend the known range of this subspecies approximately 85 miles northward and eastward in Utah.

Inasmuch as there is little recorded information concerning the habitat of these shrews, we report the following observations. Both were taken in a relatively dry meadow, in runways of long-tailed meadow mice (*Microtus longicaudus*). These runways were well defined in the grasses and sedges, and radiated out in an interconnecting network from bushes of *Potentilla fruiticosa*. Other plants in the habitat were *Carex* sp., *Descampsia caespitosa*, *Festuca montana*, *Poa pratensis* and *Poa alpina*. Other mammals taken in the same habitat were long-tailed meadow mice (*Microtus longicaudus*), deer mice (*Peromyscus maniculatus*), least chipmunks (*Eutamias minimus*) and vagrant shrews (*Sorex vagrans*). Perhaps the rarity of Merriam shrews might be the result of extensive overgrazing of western range lands. This is somewhat indicated by the fact that our two specimens were from a protected non-grazed locality.

Sorex nanus Merriam.—One specimen (skin, skull and skeleton), an adult, lactating female, number 10,880, was taken July 27, 1954, at Gooseberry Ranger Station, Elk Ridge, 8,560 feet, San Juan County, Utah. Insofar as we are aware, this is the first specimen of this species to be reported from the state of Utah. Measurements are: Total length, 89.0; length of tail, 37.0; length of hind foot, 10.0; length of ear, 5.0; condylobasal length, 14.5; palatal length, 5.9; cranial breadth, 6.9; least interorbital breadth, 2.9; maxillary breadth, 4.0; alveolar length of maxillary tooth-row, 5.3 mm.

This specimen was taken in a moderately damp and shaded forested area on the northeast facing hillside adjacent to the meadow where the two specimens of *Sorex merriami leucogenys* were obtained. The exact locality of capture was on a rocky ledge under a large, overhanging boulder. The adjacent trap contained a vagrant shrew (*Sorex vagrans*). The predominant plants in the habitat were *Populus tremuloides*, *Quercus gambeli*, *Symphoricarpos vaccinioides*, and *Poa* sp. Other mammals taken in this habitat were long-tailed meadow mice (*Microtus longicaudus*), deer mice (*Peromyscus maniculatus*), least chipmunks (*Eutamias minimus*), and vagrant shrews (*Sorex vagrans*).

A second specimen (in alcohol, skull removed for study), number 10,898, was obtained by Doctor Norman R. French, at South Cascade Canyon, 10,050 feet, Grand Teton National Park, Wyoming, on July 8, 1952. This is the second record of this species from Wyoming and constitutes the northernmost record for animals of this species. The braincase is damaged, but the following measurements are available: Palatal length, 5.5; least interorbital breadth, 2.75; maxillary breadth, 3.65; alveolar length of maxillary tooth-row, 5.2 mm. According

to Doctor French, he found this specimen dead in the snow, on a rocky tundra, above timberline.

The literature reports that there are only four and possibly five known specimens of *Sorex nanus*. They are from Colorado, Wyoming, and Arizona. With the addition of the two specimens herein reported, it is now possible to establish a larger range for this species than heretofore known. It apparently includes the mountainous areas of western and southern Wyoming, central and western Colorado, southeastern Utah and northern Arizona. The elevations of capture of all specimens are between approximately 8,000 feet and 10,500 feet, indicating that shrews of the species *Sorex nanus* are restricted to high montane habitats.—Stephen D. Durrant and M. Raymond Lee, *Department of Zoology, University of Utah, Salt Lake City. Received January 7, 1955.*

MERRIAM SHREW IN CALIFORNIA

Until the present time, *Sorex merriami* was represented in California only by a skin and skull from Siskiyou County, and two incomplete skulls from owl pellets collected in Modoc County. These three specimens are all of the race *S. m. merriami* Dobson (Benson and Bond, Jour. Mamm., 20: 348-351, 1939). The first specimen of the subspecies *S. m. leucogenys* Osgood to be recorded from the state was trapped on June 29, 1954, at Cottonwood Creek in the White Mountains of Mono County, California. It is an adult male, and is the second complete specimen of *S. merriami* to be taken in the state. It was caught on the floor of the valley (9500 ft. elevation) in a fairly dense stand of sagebrush, about two hundred yards from Cottonwood Creek. The adjacent steep slopes support mountain mahogany and sagebrush on the southerly exposures, and bristlecone pine, limber pine, and juniper on the northerly.

Measurements of the specimen are: total length, 104 mm.; tail, 41; hind foot, 12; ear, 8; weight, 6.5 gms. The teeth are quite worn. Testes, which were preserved, measure 5.5 mm. in length, and histological sections indicate full breeding condition. The color of the testes is unusual, being a bright green. The pigment appears to be localized in the interstitial cells, but its chemical nature is not yet known.

The flank glands are hairless and measure 7 x 3 mm. It is noteworthy that although males of all American members of the family Soricidae possess well developed flank glands, only in *S. merriami* are these very prominent to the naked eye. Their development appears correlated with sexual activity or maturity, since they are not prominent in an individual judged to be immature by tooth wear. The only other North American shrew to approach *S. merriami* in flank gland development is *Notiosorex crawfordi*, in which the glands, although smaller, are noticeable in an adult male. The large flank glands may be related in some manner to the arid habitat of these two shrews, or to their seeming rarity, or both.—Robert S. Hoffmann, *Museum of Vertebrate Zoology, University of California, Berkeley. (Current address: Department of Zoology, Montana State University, Missoula.) Received December 20, 1954.*

THE GRAY SHREW, *NOTIOSOREX CRAWFORDI*, IN LOS ANGELES COUNTY, CALIFORNIA

For nearly a score of years the gray shrew, *Notiosorex crawfordi*, has been known to occur in the fossil fauna of Los Angeles County, California (Compton, Univ. California Publ. Geol. Sci., 24: 85-89, 1937). George Willett (Los Angeles Co. Mus. Sci. Ser. no. 9, Zool. no. 4: 8, 1944) gave the gray shrew hypothetical listing in the recent fauna. Mr. Kenneth E. Stager of the Los Angeles County Museum has heard in recent years from his students and friends various, unofficial reports of this shrew having been seen around local wood piles and of skulls of this shrew having been found in owl pellets deposited in Los Angeles County. However, the first published record for this county recently appeared (Vaughan, Univ. Kansas Publ. Zool., 7: 532, 1954). Unfortunately, this comment on a single individual from Los Angeles County gives but little evidence of its determination and state of pre-

servation and location of specimen. What follows is offered as conclusive proof of the occurrence of this rare mammal in Los Angeles County.

In 1948 the private collection of birds and mammals of Mr. Jack H. van Nordheim was donated to the Allan Hancock Foundation. This collection contains a specimen (no. 2369) of the gray shrew that was taken at La Crecenta, 1569 ft. el., Los Angeles County, in 1942. The skull is in good condition and the study skin is fair but the label lacks information on size and sex (it is thought to be a male as no mammae are visible).

In 1950, three specimens of the gray shrew were received by the Allan Hancock Foundation from Paul O. Greeley, M.D., Director of Student Health Center (formerly an instructor in Biology), University of Southern California. One specimen was collected in April, one in May, and one in June. They came from Dr. Greeley's ranch in Mint Canyon, 3½ mi. S. W. of Oaks, 1800 ft. el., Los Angeles County. All three shrews were taken in the night by the house cat and deposited on the doorstep. The fresh specimens were promptly delivered to me by Dr. Greeley. The first shrew (no. 2765, ♀) was preserved whole in alcohol, the other two (nos. 2766 and 2767, both ♂♂) were made into skins with skulls and incomplete skeletons. All four of our specimens appear to be subadult because of the relatively short head-body length, little-worn teeth, and poorly fused sutures on the bulging crania.

Available measurements in millimeters of these four gray shrews (nos. 2369, 2765, 2766 and 2767) are as follows: Total length,—, 88, 80, 85; length of tail, —, 26, 24, 25; length of hind foot, —, 10, 10, 10; length of ear (from crown), —, 4, 3, 4; (from notch), —, 4.5, 4, 5; weight in grams, —, 3.7, 5, 4. Skull measurements: condylobasal length, 16, —, 16.9, 17.2; palatal length, 6.7, —, 6.8, 7; cranial breadth, 8, —, 8.2, 8.3; cranial depth, 4.5, —, 4.7, 4.7; interorbital breadth, 3.7, —, 3.8, 3.9; maxillary breadth, 4.7, —, 4.9, 5; tooth row from front of second incisor, 5.9, —, 5.9, 6.4; respectively.

Through the courtesies of Mr. Kenneth E. Stager and Mr. James R. Northern, I report the taking of a fifth specimen of the gray shrew from Los Angeles County. Mr. Northern trapped an adult female in the Covina Hills, 600 ft. el., E. of Covina, on April 22, 1951, field no. 45, measurements: 73 mm., 24, 10, 7. It was recently donated to the Los Angeles County Museum by Mr. Northern. The specimen is an alcoholic in fair condition except for slipping hair on vent and belly. The skull has been removed and cleaned. Measurements, in the same order as those for skulls above, are: 16.8 mm., 7.6, 7.7, 4.4, 3.7, 4.8 and 6.9. The measurement recorded for ear is greater than expected; however, the ears of the specimen appear to be the size of those in the Hancock collection.

For several years the gray shrew has been known to occur in the recent fauna of the following counties in Southern California: Santa Barbara, Ventura, San Bernardino, Riverside, San Diego, and Imperial. This report extends the known range to include Los Angeles County.

The uniformity of characters throughout the range of this subspecies, as well as the similarity between the skulls taken at various levels in the tar pits and those of recent specimens have been pointed out by others. Our specimens and the one at the Los Angeles County Museum agree in size and coloration with those of the subspecies *crawfordi* examined at the Museum of Vertebrate Zoology.—FLOYD E. DURHAM, *Allan Hancock Foundation, University of Southern California, Los Angeles.* *Contribution of the Allan Hancock Foundation, no. 161. Received January 2, 1955.*

DENTAL ABNORMALITIES OF THE ALASKAN FUR SEAL

Most variations in dental formulae of pinnipeds are probably due to the loss of teeth and the subsequent bony alveolar obliteration. These abnormalities make identification of the skulls somewhat difficult and may be the cause of systematic or taxonomic disagreements. For example Forbes (Trans. Zool. Soc. Lond., 11: 225-231, 1881) states, "As regards the genus *Zalophus*, it may be noted that Mr. O. Thomas has lately noticed a skull of *Otaria jubata* with the same number of molars as are supposed to characterize that genus (P.Z.S. 1881, p. 4)."

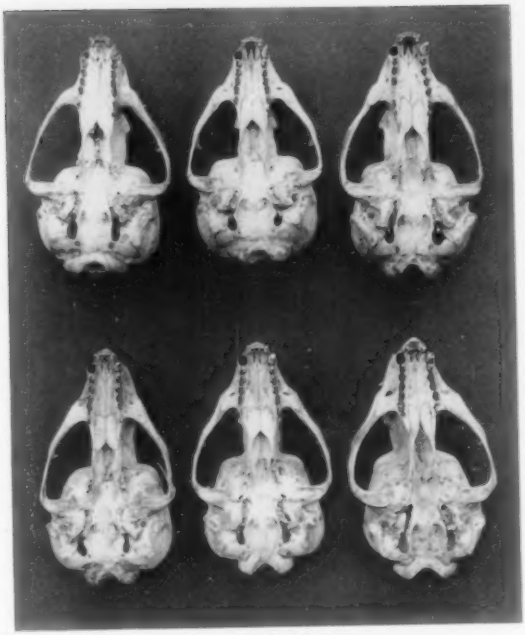

PLATE I

Female Alaskan fur seal skulls. Specimens from left to right, upper: 1875; 1573; 1107; and lower: 1497; 2809; 2838. See description in text. *Photograph by J. B. Phillips, California Fish and Game.*

In connection with a study on the morphology of the Alaskan fur seal (*Callorhinus ursinus*), the U. S. Fish and Wildlife Service supplied, among other materials, a series of 38 female fur seal skulls. These skulls were selected for sex but otherwise were random choices from the Fish and Wildlife Service collection. Of these 38 skulls, six were abnormal in their dentition. No precise ratio of abnormalities should be drawn from a series this small but it seems certain that a high incidence of dental irregularities does occur among these mammals.

The normal dental formula of the Alaskan fur seal is I. 3/3; C. 1/1; and postcanines 6/5 x 2. For reasons as yet unpublished, the teeth posterior to the canines should not be designated as premolars and molars. All postcanine teeth (except the sixth postcanines of old adults, which are quite small) are similar in structure and size. All teeth are usually single rooted; however, the postcanines are sometimes secondarily double rooted. The structure of the crown of the postcanines is best described as peglike. In general, the dentition may be termed weak.

Plate I shows the dental abnormalities in the six female skulls. Skull 1875, upper left of the figure, has six teeth posterior to the canine on the left and only five postcanines on the right. There is also a greater space between the fourth and fifth postcanine teeth on the right side than occurs on the left. Specimen 1573, upper center, also has six postcanines on the left and only five on the right, but these are evenly spaced. In the latter specimen the sixth left postcanine is degenerate or malformed. Specimen 1107, upper right, is lacking the fourth upper right postcanine tooth. Specimens 1497, lower left, and 2809,

ower center, have only five postcanine teeth on either side, and specimen 2838, lower right, has only four postcanines on the left. This latter specimen also has a partially "involuted" alveolus of the left, fifth postcanine tooth.

If a tooth is lost while bone formation is progressing it seems likely that the alveolus of the lost tooth would fill in with bone. This is undoubtedly the case with the "involuted" alveolus of the left, fifth postcanine of specimen 2838. The loss of teeth is considered unusual among most wild mammals, but there are numerous examples of a situation in humans similar to that shown by skull 2838, and most senile human skulls show no trace of the alveolus of lost teeth.

It is well known that the dentition of pinnipeds is weak and, as mentioned above, the teeth are generally single rooted. The root canal is often closed in individuals as young as seven or eight years. This closure is due mainly to accumulation of cementum on the root.

Fur seals are predaceous mammals feeding mainly on large invertebrates and fish (Scheffer, U. S. Fish and Wildlife Service, Wildlife Leaflet 329, 1950). Rocks are often found in the stomach although the reason for their presence is unknown.

Due to the poorly rooted condition of the teeth and the consistency of the food and other materials swallowed, it seems probable that accidental extractions would occur rather frequently. Accidental extractions are also possible in other ways, especially during the fighting that precedes mating.

The bony alveolar replacement also suggests a possible explanation for "supernumerary" teeth in some pinnipeds. Allen's (U. S. Geol. & Geog. Sur. Terr., Misc. Publ. 12, 1880) description of *Zalophus californianus* dentition includes the following, "When more than five upper molars are present, the sixth or supernumerary is posterior to the fifth, and is usually smaller than the fifth (sometimes almost rudimentary) and lacks the accessory cusps seen in the fifth."

This description is similar to that given for the sixth upper postcanine tooth of *Callorhinus*, except that *Callorhinus* normally has this tooth. In fact, it may actually be that the sixth upper postcanine of *Zalophus*, which Allen mentions as supernumerary, may normally be present. If the tooth is deciduous as in the fur seal, (the evidence for this statement was presented to the Southwestern Division of the A.A.A.S. meeting at Tempe, Ariz., Apr. 20, 1953) then it is normally lost. If it is permanent it could also be lost quite easily rather early in life. In either event the involution of the alveolus would erase any trace of its former presence.

Due to the fact that fur seals may replace the sixth upper postcanine, this deciduous tooth might, upon accidental extraction, be replaced by the permanent tooth. Hence, the chances of the alveolus being involuted are decreased. It appears however, that the deciduous tooth is not always replaced. If the deciduous tooth is lost very early (soon after eruption) the development of the permanent tooth may be suppressed. Subsequent extension of the jaw may then result in a diastema between the fourth and fifth postcanines as seen in specimen 1875.—Robert B. Chiasson, *Department of Biological Sciences, Stanford University, Stanford, California.* *Received January 11, 1955.*

LIGHT PENETRATION IN RELATION TO SMALL MAMMAL ABUNDANCE

Microtus pennsylvanicus usually seems to be most abundant in the heaviest grassy cover of an area. Eadie (Jour. Mamm., 34:263–264, 1953), reported on relative vole abundance in a quarter-acre quadrat of an uncut timothy field. He found that the area of high mouse numbers as measured by bait acceptance ". . . had almost twice as much vegetative cover as the area of low acceptance." To measure cover he air dried and weighed all vegetation taken from small random plots in the "high" and "low" areas.

I decided to see if the same general results would be obtained using the "dropping board" method (4 in. x 4 in. squares of ¼ in. plywood—Emlen *et al.* in MS.). The "Grady Tract" of the University of Wisconsin Arboretum, where this work was carried out, includes a large "man made" though quite typical long grass prairie and also an area of "unimproved" grassland. One hundred numbered dropping boards were placed 30 paces apart along three

parallel lines transecting both types of herbaceous vegetation. Records were not complete for three boards, hence the calculations for this paper are based upon 97 of the 100 boards.

A Weston photoelectric meter, model 603, was used to measure the light coming through to ground level, thus getting an indirect measure of vegetative cover. When such determinations are made in an homogeneous stand, they also yield an indirect measure of vegetation density. In order to be able to compare results from one area and time to the next it is probably necessary that all readings be taken with the sun unobscured by clouds and at approximately the same height above the horizon (Køie, Oikos, 4: 178–186, 1952–53; Sather, Jour. Wildlife Mgt., 14: 138–143, 1950). In spite of these restrictions, I feel that this technique is to be recommended because of the rapidity with which satisfactory data can be collected. As far as I know, no one has yet determined the relative importance of vegetative "cover" (amount of sky or ground masked by the vegetation, expressed as a per cent) as opposed to "density" (number of stems per unit area) in influencing use by small mammals. It is also possible that cover composed of very thin translucent leaves may be just as good from a small mammal's point of view as cover of the same size and number of very opaque leaves.

Due to low mammal densities, the dropping boards were checked four times at two or three day intervals and the droppings of *Sorex*, *Blarina*, *Microtus*, *Peromyscus*, and *Mustela rixosa* were considered together. Disturbing the vegetation as little as possible, four light measurements of the zenith were made from ground level approximately eight inches from each side of every board. With this particular photoelectric meter (Weston Model 603) it is easy to obtain measurements of light at a level in the vegetation that is very close to that actually occupied by small mammals, a feature not found in the apparatus described by John H. Sather (*Ibid.*). Such readings are possible with the Weston meter because its photronic cell is located in a small, rather narrow paddle (18.3 x 5.0 x 1.5 cm.). The paddle is connected by wires to the small easily carried box containing the rest of the photoelectric apparatus. All light measurements were made after the observations on droppings had been completed. Frequent unobstructed readings of the zenith were also taken. The four figures obtained around each board were averaged and divided by the unobstructed reading, thus giving the mean percentage of available light that penetrated to the ground. Figure 1 shows these percentages grouped and averaged.

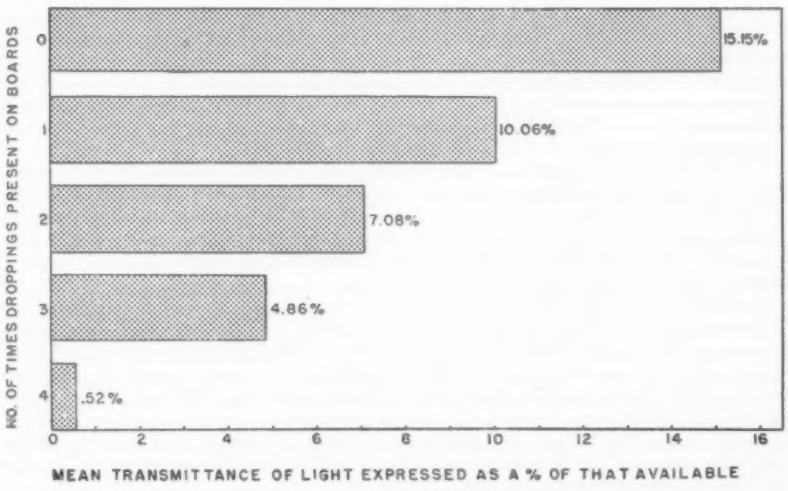

FIG. 1

Statistical comparison of all unvisited boards with all those visited at least once, gave F = 4.34*, evidence that there probably was a real difference in the light transmission at the used and unused boards. This then offers further evidence of the positive correlation between abundance of small mammals in grassland habitats and the amount of herbaceous vegetation.—ARCHIE S. MOSSMAN, *Department of Zoology, University of Wisconsin, Madison. Arboretum Journal series #31.* *Received January 3, 1955.*

NOTES ON THE BEHAVIORAL DEVELOPMENT OF CAPTIVE RED-BACKED MICE

The data herein contained were taken from a litter of five red-backed mice, *Clethrionomys gapperi*, born in captivity on August 22, 1954, to a female that had been captured on August 17 at Taborton, Rensselaer County, New York. I am indebted to William Kelly of Albany, who caught the mouse and brought her to me.

The physical development of young red-backed mice of the species *C. rutilus* has been discussed in detail by Morrison, Ryser and Strecker (Jour. Mamm., 35: 376–386, 1954). Since the descriptions given there are closely similar to events noted for the young involved in this study, this note deals primarily with the development of various aspects of the behavior pattern, and their time of appearance in young individuals.

Within one day after birth the young were capable of vocalization. Shrill and almost inaudible squeaks were heard at this time. The young were hairless and helpless, practically incapable of moving about. At the age of four days, they gained some sense of equilibrium and remained right side up most of the time. At five days, they began to crawl about the cage, albeit slowly and awkwardly. One of the five young died at this age, and the following observations were made on the remaining four.

After the sixth day, the young held so tightly to the mother's nipples that it was difficult to dislodge them for weighing and examination. At seven days the most advanced individual had developed both pairs of incisor teeth to the extent that it could gnash them when it was handled. In all four, gnashing of teeth occurred as soon as the incisors appeared.

When they reached eight days of age, the young mice crawled about freely but awkwardly, with hind legs at right angles to the body. One protested with squeaks when handled, the first vocal protest. At nine days, equilibrium was sufficiently good that they could scratch themselves with a hind foot. Coordination was improving, but they still jerked and twitched a great deal. The eyes of the most advanced individual opened at this age.

On the tenth day, they began to crawl off the pan of the scales when weighed, and one sucked at my finger while being carried back to the cage. At eleven days, one sat up and washed its face with its forepaws, while another made an attempt to do the same, but was unable to retain its equilibrium. Another, which did not yet have its eyes open, sat up in defense posture when touched. At this time they were capable of crawling over an obstacle one-half inch in height.

At twelve days, the eyes of two were fully open; the other two attained this status a day later. The same individual that had assumed defensive posture the day before now sat up, bared his teeth, squeaked, and boxed at my finger with his forepaws. Another, the most advanced physically of the four, crawled over the edge of a box with two-inch vertical sides, though he himself was only about three inches in length. All of them were now capable of walking quite efficiently and could run awkwardly.

At thirteen days, when all had their eyes open, they assumed the trait, normal in adults, of sticking their noses through the nest material, sniffing and peering around when the top of the cage was opened. They were able to climb at a 45° angle up my arm, but did not climb around the sides of the cage. On the fourteenth day, they were first seen climbing on a vertical surface, the one-quarter inch wire mesh sides of their cage. One escaped from a fruit basket with nearly vertical three-inch sides by jumping up and getting his forepaws over the edge, and pulling himself over. For the first time it was evident that they were doing their own grooming, for they spent much time in washing and cleaning their fur. At this age, they took solid food for the first time.

At fifteen days the mother seemed to be making some effort to wean the young, and they were completely weaned at seventeen days. On this day, they made the first effort to escape capture by running about the cage, and two of them urinated when picked up. They were then separated from the mother, and were from then on generally similar to adults in behavioral characteristics.—ALLEN H. BENTON, *New York State College for Teachers, Albany, New York. Received December 12, 1954.*

MYOTIS KEENII IN FLORIDA

I collected one adult female *Myotis keenii septentrionalis* in Old Indian Cave three miles north of Marianna, Jackson County, Florida, on October 30, 1954. The bat was torpid when first picked from the wall of the cave. Upon skinning it I found heavy deposits of fat; it weighed 7.2 gms. It was hanging by itself, although the same chamber of the cave contained about 1500 *Myotis austroriparius* hanging in several large clusters, and about 4000 *Myotis grisescens* in many smaller clusters; in addition 75–100 *Pipistrellus subflavus* were present.

The next nearest locality records for *Myotis keenii* are Marion County, Tennessee, and Towns County, Georgia (Miller and Allen, Bul. U. S. Natl. Mus., 144: 106–110, 1928); thus this record extends the known range 290 miles south. The one individual was probably a migrant from farther north, or possibly it represents an isolated local population, analogous to the local population of *Myotis grisescens* (Rice, Jour. Mamm., 36: 289–290, 1955). Exploration of a dozen other caves in the vicinity and three miles farther down the Chipola River on October 30 and 31 failed to reveal any additional individuals of *Myotis keenii*. I returned to Old Indian Cave on December 11 and found no *Myotis keenii*. To determine its status in the region more investigations of the caves during the winter are needed, in addition to shooting during the summer months, since it does not breed in the caves like *Myotis grisescens*.

Identification was by the writer. The skin and skull are now No. 1043 in the University of Florida Department of Biology mammal collection.—DALE W. RICE, *Department of Biology, University of Florida, Gainesville. Received January 3, 1955.*

MYOTIS SODALIS IN WISCONSIN

A specimen of *Myotis sodalis* taken from an abandoned lead mine in southwestern Wisconsin represents the first record of this species for that state. The bat was taken from a mine known as Atkinson's Diggings, two and a quarter miles west of Beetown, elevation 850 feet, Grant County, Wisconsin, on November 7, 1954. This individual was discovered among 274 *Myotis lucifugus* which the writers had gathered for banding. It was the only *M. sodalis* seen. The specimen, a female, has the following measurements: total length, 91 mm.; length of tail, 37; hind foot, 9.5; and ear, 14.5. The specimen is now number 7191 in the collection of the University of Illinois Museum of Natural History.

The northern limits of the known range of this species in the Midwest now extend to southeastern Michigan, southern Wisconsin, and central Missouri.—WAYNE H. DAVIS AND WILLIAM Z. LIDICKER, JR., *Museum of Natural History, University of Illinois, Urbana. Received December 15, 1954.*

WEASEL PREYS ON LARVAL SALAMANDER

On August 27, 1954, while on a short hike up the Wahkeena Falls Trail in the Columbia River Gorge east of Portland, Oregon, Mr. and Mrs. T. D. Kirkpatrick, my wife and myself had the opportunity of watching a weasel (*Mustela frenata*) hunting. The animal was first seen coming up the trail over which we had just walked. It nosed along checking all the holes in the rocks, and under the roots of an overturned tree near the foot of Fairy Falls. From here it went to the rocks along the stream and began systematically ducking under the water and searching among the rocks. After going back and forth along each bank about ten feet it made a grab among the rocks and came out with a larval giant salamander (*Dicamptodon*) about five inches long. As I slowly reached out to capture it, it continued

chewing until finally becoming concerned about my hand a few inches above its back. As I grabbed, it ran, leaving the salamander a few feet away. The weasel apprehensively moved back and forth in the brush a few feet below us, watching our actions.

Since the salamander's brains were well exposed, the weasel had apparently made a clean kill. We left the salamander beside the stream in the trail where it had been dropped by the weasel. A half hour later as we returned down the trail we were unable to find the weasel's prey.

A weasel would not normally be expected to behave in this manner as much as a mink. However, it was seen at close range that the animal was very light colored on the underside and the upper parts were brown. The tail had a black tip. The animal was estimated to be 15 inches in total length. A look at skins in the museum collection convinced me that it was a weasel I had seen.—FRANKLIN W. STURGES, *Oregon State College Museum of Natural History, Corvallis. Received December 27, 1954.*

AN ADDITIONAL RECORD OF *MUSTELA ERMINEA* FROM UTAH

In the night of September 10, 1954, I trapped a male ermine, *Mustela erminea muricus* (Bangs), one-half mile east of Soldier Summit, in Wasatch County, Utah. I had set 42 hardware-cloth, 2½″ x 2½″ x 10″ live-traps and 45 Museum Special mouse-traps in grass along a moist swale and near head-high thickets of *Salix*. The ermine was found, alive in a live-trap with a dead *Peromyscus maniculatus*, at the edge of a thicket the next morning. Part of the head including the brains of the *Peromyscus* had been eaten. I surmise that the ermine entered the trap containing the *Peromyscus* by lifting the sheet-metal trap door which was hinged at the top of the trap and could be pushed inward. Other mammals trapped at this locality were five additional *Peromyscus maniculatus rufinus* and three *Microtus montanus amosus*. The scarcity of records of the ermine and of many other "rare" mammals is probably not a result of their actual rarity but of the collecting methods commonly employed and of the habits of the animals. Many of the ermine recorded from the Rocky Mountains were taken, as was the above specimen, "accidentally" in mouse-traps. Live-traps of a slightly larger size than those mentioned above and baited with living *Peromyscus* or other small rodents might prove a useful method of collecting *Mustela erminea*. External measurements in millimeters of the specimen, catalogue number 63329 in the Museum of Natural History, are as follows: total length, 227; length of tail, 60; length of hind foot, 30; and height of ear from notch, 15.—SYDNEY ANDERSON, *Museum of Natural History, University of Kansas, Lawrence. Received January 3, 1955.*

A LOW ALTITUDINAL RECORD OF THE SIERRA NEVADA PINE MARTEN

On October 6, 1954, Mr. Gene Gerdes, California Department of Fish and Game, Bishop, and I found a male Sierra Nevada pine marten (*Martes americana sierrae*) that had been killed by an automobile one half mile west of the city limits of Bishop, Inyo County, California on West Line Street. Bishop lies in Owens Valley close against the precipitous eastern slope of the Sierra Nevada at 4,200 feet elevation on a Piedmont plain sloping out from the base of the mountains. The surrounding vegetation is typical of the Upper Sonoran Zone of the Great Basin and is composed of rabbitbrush (*Chrysothamnus teretifolius*), rubber rabbitbrush (*Chrysothamnus nauseosus*), blackbush (*Coleogyne ramosissima*) and associated species. The nearest trees are pinyon pine (*Pinus cembroides* var. *monophylla*) at about 6,000 feet and four airline miles away. Typical marten habitat at 9,000 feet is present eight airline miles away.

The precipitousness of the eastern Sierran slope often causes wandering animals to be found far from their normal altitudinal range, though they may have traveled only a very few airline miles. However, Grinnell *et al.* (FUR-BEARING MAMMALS OF CALIFORNIA, 1937) state that though marten in the central Sierra Nevada were known to make occasional trips down to 6,000 feet in the Transition Zone, lower excursions were not known. He gives their normal range as above 7,000 feet in this area near coniferous forests in the Hudsonian and Canadian zones.

This record at 4,200 feet in the sagebrush type of the Upper Sonoran Zone is, therefore, an instance of unusual wandering.—Fred L. Jones, *California Department of Fish and Game, Fresno. Received January 3, 1955.*

RECORDS OF SOUTHERN WOLVERINE, *GULO LUSCUS LUTEUS*, IN CALIFORNIA

Ruth (Jour. Mamm., 35: 594, 1954) reports a recent observation of the wolverine in California. Jones (California Fish and Game, 36: 320–322, 1950) reported on sixteen recent records. Since that time nine additional observations have come to light.

In 1938 Bill Carrasco, Lone Pine, California, cattleman, saw one in Little Five Lakes Basin, Tulare County, at 10,000 feet elevation. In 1938 Carrasco also saw two at Bullfrog Meadow, near Tunnel Meadow, Tulare County, at 9,000 feet. In June, 1950, Jim Loundagin, California Department of Fish and Game, Bishop, saw what he believed to be a wolverine at the inlet of Crooked Creek into Crowley Lake, Mono County, at 6,700 feet. In September, 1950, an unidentified Lone Pine resident reported seeing one in a tree on Shepherd Creek, Inyo County. In July, 1951, Allie Robinson, packer, Leavitt Meadows, stated that several people had reported seeing one near the junction of Highways 108 and 395 in Mono County, at 7,000 feet.

In August, 1951, Howard Bilton, California Department of Fish and Game, Glennville, saw tracks of one on the Sandy Creek Fire Road on the west side of Greenhorn Mountain, Kern County, at 5,000 feet. In July, 1953, Bilton followed tracks of one in the trail for 4–5 miles between Painter Flat and Hole-in-the-Ground on the Kern River, Tulare County, at 6,500 feet. In October, 1953, Don Hall, California Department of Fish and Game, Cartago, killed one that had been crippled by a deer hunter about three miles east of Onion Valley, Inyo County, at 8,000 feet. In November, 1953, Jerry Mankins, California Department of Fish and Game, Fresno, photographed tracks of one in the Camp Six area near Barton's Flat, Fresno County, at 6,500 feet.—Fred L. Jones, *California Department of Fish and Game, Fresno. Received January 3, 1955.*

OCCURRENCE OF *PEROMYSCUS*

Studies of small mammal occurrence at high altitudes in the Sierra Nevada are uncommon, so the opportunity for even a short examination was welcomed. The period of August 17–26, 1954, was spent at lower Graveyard Lake, 9,900 feet, Sierra National Forest, Fresno County, California. This locality is approximately eight miles from the nearest jeep road.

A northeast slope of approximately 45 degrees, leveling off near the top, was arbitrarily picked for the study. Nothing was known or was learned of the comparative characteristics of adjacent areas of other exposures and degrees of slope. The soil was granitic in its entirety and was gravelly in nature, except in the meadows where it was loamy in texture and contained some humus. As illustrated (Fig. 1), a low form of willow (*Salix orestera*) was common over the center of the plot, with meadow bordered by willow at the top. The common herbaceous species, in the meadow and interspersed in the willow, was *Carex exserta*. The sides and most of the bottom of the plot, as illustrated, were open, rocky, and almost bare of herbaceous vegetation. Small lodgepole pine (*Pinus contorta*), an occasional white-bark pine (*Pinus albicaulis*), and one well-grown, mountain hemlock (*Tsuga mertensiana*), were found scattered over the slope, but could not be determined to influence the distribution of the animals in question.

Twenty-five Number 0 "Havahart" live traps were set on a grid pattern, 42 feet apart. This was meant to cover approximately one acre. Ten "Museum Special" snap traps were set, for eight nights, 200 feet northwest of the plot, in a rocky, well forested area, and ten were set, for 2 nights, 200 feet southwest, in an edge area between willow and heavy rocks. These latter sets were to determine drift, if any, and to pick up specimens for study skins. Live-trapped animals were marked by clipping toes, and then released. Rolled oats was used as bait. Trapping was started on the night of August 18, and ended on the morning of August 26.

From all types of trapping and observation, six species of small mammals were known to live on the plot, or in similar habitat adjacent to it: the long tailed meadow mouse (*Microtus longicaudus*); the heather vole (*Phenacomys intermedius*), one specimen of which was taken near the lake in a snap trap; the dusky shrew (*Sorex obscurus*), one specimen of which was taken in a snap trap southwest of the plot; one unidentified chipmunk (*Eutamias* sp.), taken, marked, and never retaken, and the deer mouse (*Peromyscus maniculatus*). One weasel, apparently the long tailed weasel (*Mustela frenata*) was seen once, and actions of birds indicated its presence two other times.

In eight nights (200 trap nights) of live trapping, seven different individuals of *Peromyscus* and two of *Microtus longicaudus* were taken, marked, and released. The line of snap traps to the northwest yielded one heather vole and four *Peromyscus* in 80 trap nights, but two traps were dragged away indicating the possibility of two additional captures.

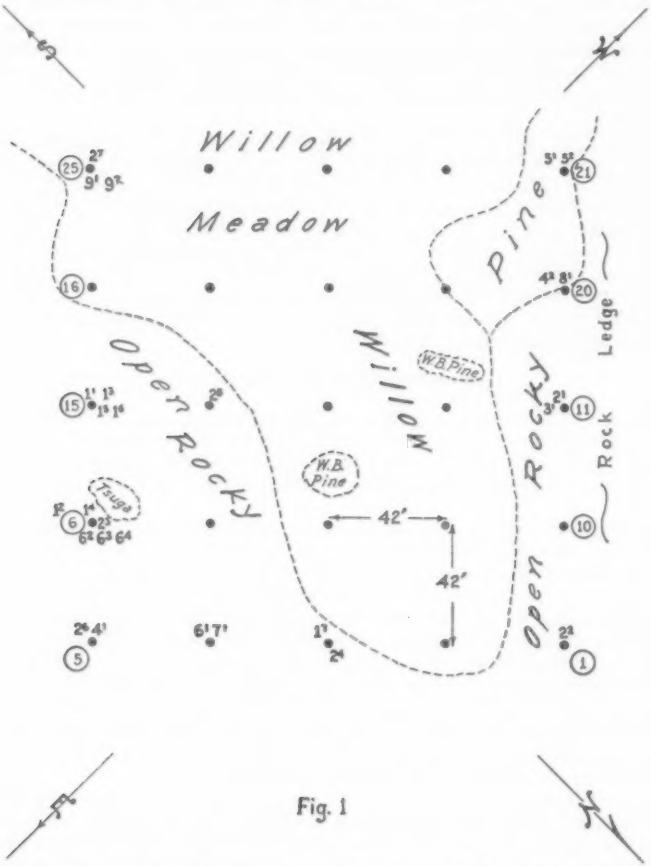

FIG. 1.—Circled numbers indicate the order of traps. The lake and lower edge of the slope are to the northeast. Numbers 1-7 are *Peromyscus maniculatus* and 8-9 are *Microtus longicaudus*. Exponent numbers indicate the order of trapping.

The line to the southwest yielded one long-tailed meadow mouse, two *Peromyscus*, and the one shrew in 20 trap nights.

The retrapping pattern, as shown on Figure 1, gives some indication of the range of activities of one species, *Peromyscus maniculatus*. Numbers 1, an immature male, and 6, an immature female, showed an attachment for one particular area. Number 3, a male, caught first at trap 11, was next caught, the following night, 223 feet northwest of that spot in a snap trap. The route was through rocks, white-bark and lodgepole pine, and mountain hemlock, but no meadow or low, willow-covered areas were crossed. Number 2, a male, gives the best picture of the possible movements of this species here, and also gives its habitat preferences. This mouse, as Figure 1 shows, traveled almost all of the way around the plot. It was caught on seven of the eight trapping nights, and was caught in a different place each time. Most of its activity, however, appeared to be centered in the eastern corner, which was rocky and open. Number 4 can be seen to have covered much distance in one night. The sexes here were about equally divided, and no sexual activity was found. With all the indication of much movement elsewhere, the meadow and willow covered areas were very unproductive. As can be seen, the only such place a *Peromyscus* was taken was in trap 25, which was at the meadow edge. The only reason that can be advanced for this lack of use is that the meadow was consistently colder, if frost is an indicator, than the rocky areas about it. Unfortunately no thermometer was kept here for comparison.

Numbers 1 and 5 were taken during the daytime on two occasions, indicating some diurnal activity. Only one specimen was taken before 10 PM, the last hour the traps were examined before morning. Nightly minimums, about 40 feet below the plot, ranged from 26 to 42°F., but no correlation between activity and temperature could be made. Number 5 was brought home and kept from August 26 to October 10 on dry food and without water. It died on the latter date, cause unknown, but it showed no signs of emaciation, and had survived many hotter days with no apparent distress. It had been active, had eaten well, and had become quite tame during that period.

The materials used on this study were supplied under Public Health Research Grant E-723, for another project. Mr. George C. Jensen made the sketch from field notes, and Dr. C. H. Quibell, Fresno State College, assisted in several ways.—ALBERT C. HAWBECKER, *Fresno State College, Fresno, California.* *Received November 25, 1954.*

A POPULATION-HIGH FOR *PEROMYSCUS MANICULATUS*

Irruptive populations of *Peromyscus maniculatus* occasionally have been reported, but generally no data on population structure are available. A very dense population was encountered in June, 1954, in the White Mountains of Mono County, California. In a period of eight days of snap trapping in Cottonwood Creek basin, 9500 ft. elevation, 528 *P. maniculatus sonoriensis* were taken in 1204 trap nights. Animals were classified as to sex and age class (adult or juvenile). During the first two or three nights, the catch rate closely approached or attained one mouse per trap night; thereafter the rate declined.

Other small mammals trapped in this period included 10 *Microtus longicaudus*, 15 *Microtus montanus*, and 12 *Sorex palustris*, all in riparian grass and *Carex* marshes; 2 *Lagurus curtatus* and 1 *Peromyscus truei* in dry washes of rock and sand, and 1 *Peromyscus truei* and 1 *Sorex merriami* in sagebrush. The trap line also sampled mixed grass and sagebrush.

Unfortunately, the numbers of *P. maniculatus* from the different vegetational situations were not segregated in the tally, but approximately equal catch rates were apparent for all of the situations. Thus, *P. maniculatus* seemed to be almost as abundant in the *Carex* marshes as in the sagebrush. The spread into vegetation types other than sagebrush, which is normal habitat for the species in this area, might be explained in terms of "pressure" exerted by the high population. Another manifestation of this pressure may be found in the maintenance of high catches throughout the trapping period. In addition to the field trap lines, ten traps were kept set for seven days around the camp garbage pit, located in a riparian willow thicket. In these 70 trap nights, 68 *P. maniculatus* were caught, in-

TABLE 1.—*Catch of P. maniculatus in the vicinity of Cottonwood Basin (9500 ft. elevation), White Mountains, Mono Co., California, in 1917 and in 1954*

Date, field party	*P. maniculatus*				Trap nights	Catch/trap night
	Sex	Adults	Juveniles	Total		
July 25–Aug. 3, 1917, Grinnell, Shelton, and White	♂♂	50	8	58		
	♀♀	56	19	75		
Total		106	27	133	1463	0.09
June 21–28, 1954, Russell, Leopold, Williamson, and Hoffmann	♂♂	54	140	194		
	♀♀	87	200	287		
	unclassified	—	—	47	1204	0.44
Total		141	340	528		

dicating continual replacement of the trapped individuals. Almost all of the mice were caught at night. No unusual diurnal activity was noted.

The sex and age composition of the catch is shown in Table 1. Only 30 per cent of the sample was composed of fully adult animals. This might be expected in an early summer population that presumably attained a high level through active reproduction in the early spring, with subsequent low mortality. It is surprising, however, that there was no evidence of reproductive activity in the trapped animals, although all were examined for external indications of pregnancy, lactation, or testes in a scrotal position. In addition, ten adults (5 ♂♂, 5 ♀♀) were autopsied. Placental scars, but no embryos, were found in the females, and the testes of the males apparently were regressing.

More females than males were caught, and this was true of the juveniles as well as of the adults. Usually males are reported slightly to outnumber females in catches of *P. maniculatus*, a situation ascribed in part to the greater mobility of the males. It is of interest that the same preponderance of females was found in the catch of *P. maniculatus* made in the same area by Grinnell, Shelton, and White, in 1917 (unpubl. field notes) at a time when the population seemed to be moderately low (Table 1).

Finally, in contrast to some other peak populations reported, the other species of small mammals in the area did not achieve high population levels. This general situation of a high *P. maniculatus* population, coupled with low numbers of other small mammals, was encountered at all places visited in the White Mountains, although no records of numbers caught were kept at other camps.—ROBERT S. HOFFMANN, *Museum of Vertebrate Zoology, University of California, Berkeley. (Current address: Department of Zoology, University of Montana, Missoula.)* *Received December 20, 1954.*

THREE *NEOTOMA* POPULATIONS IN GEORGIA AND INTERPOPULATION MATING IN CAPTIVITY

From October, 1951, until April, 1954, several collecting trips were made in Georgia and a few immediate areas for the purpose of live trapping *Neotoma* to use in breeding experiments. This has also resulted in some clarification of statewide distribution. This particular region well represents the southeastern forms since *N. magister* Baird, *N. floridana floridana* (Ord), and *N. floridana haematoreia* Howell all occur within the state. It is interesting to note that a definite hiatus exists between these populations. *N. floridana*

floridana occurs throughout most of the Coastal Plain but is never seen much above the Fall Line in Georgia. *N. floridana haematoreia* occurs in the Appalachian Mountains where they extend into the northeast portion of the state. *N. magister* occurs on the Lookout Plateau (Appalachian Plateau Province) in the Dade County area. This leaves most of the Piedmont and the Ridge and Valley Province between the two mountain districts with no known records for Neotoma.

On October 31, 1953, an immature female of *N. floridana haematoreia* was captured by hand in a rock building on the top of Blood Mountain on the line joining Lumpkin and Union counties, Georgia. (This is the type locality for the subspecies.) This individual was kept alone in a cage until April 19, 1954. On this date it was placed in a 4 x 3 x 3 foot cage with a fully mature male of *N. floridana floridana*. This latter individual was live trapped on April 1 in an abandoned corn crib on the area of the Savannah River Plant, Aiken County, South Carolina. This pair remained together until about the middle of May but were then separated because of the very poor condition of the female, which had several open wounds and a portion of the tail missing. But even with this apparent incompatibility two young were born to the female sometime between May 28 and 31. On June 3, however, the young were found dead in the cage. Their death may have been due to the unnatural environment rather than to any genetic weakness.

The male was placed with the above female again from July 10 until 21 as well as with other females from other localities for short periods but in each case fighting resulted with considerable injury to the females. No other births occurred.—William H. Cross, *Department of Biology, University of Georgia, Athens. Received December 19, 1954.*

A RECORDED INSTANCE OF SUPERFETATION IN THE GOLDEN HAMSTER

In our colony of golden hamsters (*Mesocricetus auratus* Waterhouse), on which extensive breeding experiments are in progress, a number of instances have been recorded in which a pregnant female will display a recurrence of heat, and accept the male.

The example reported here was of a female that came into heat nine days following breeding (normal cycle is 4 days) and was re-bred. At 16 days following the first breeding, she gave birth to a litter during the night, but consumed them all. Nine days later the same female delivered ten young. This evidence of superfetation in the hamster would add to similar examples reported in other species and support the possibility of sperm transport through an already impregnated uterus.

This investigation was supported by Public Health Service Research Grant No. G-4213.—
A. L. Soderwall and Alice L. Britenbaker, *Department of Animal Husbandry, Cornell University, Ithaca, N. Y. (Current address: University of Oregon, Eugene.) Received January 11, 1955.*

BLAINVILLE'S BEAKED WHALE, *MESOPLODON DENSIROSTRIS*, ON THE TEXAS COAST

Moore (Amer. Midl. Nat., 49: 117–158, 1953) noted the probable presence of this rare whale in Florida waters but he had no record. Similarly, (Gunter, Chap. XX, *in* Fish. Bul. 89, Fish and Wildlife Service, 1954) gave no record in a summary account of the marine mammals of the Gulf of Mexico. Therefore, when I realized later that good evidence of a stranding on the Texas coast had been in my files for several years, it was with considerable dismay. This note is written to fill out the record and to rectify the previous omission.

The decaying carcass of this whale was found on the Gulf beach of Padre Island about 25 miles south of its northern end (40 miles south of Port Aransas, Texas) by Mr. Ben Martin in the first part of September, 1946, following the passage offshore of a hurricane which caused high tides along the south Texas coast. He took eight photographs of the specimen, two of which show the large single tooth in the midregion of the lower jaw, characteristic of this species. One tooth was sent to The American Museum of Natural History, where it was identified by George G. Goodwin as that of *Mesoplodon densirostris*.

He informed Mr. Martin of this fact in a letter dated September 20, 1946, and asked to be allowed to keep the specimen for the Museum's collection. This letter and the photograph were given to me by Mr. David Kramer, to whom I am indebted, and were filed away too well as stated above. After the information was resurrected I interviewed Mr. Martin at Port Aransas. He averred that the animal was a male and was 16 feet long or more. None of the skeleton was saved and it has long since been buried without marker or trace by the continuously blowing sands of this wind-wracked coast. Nevertheless, the above information is adequate to establish the stranding of *Mesoplodon densirostris* on the coast of south Texas, and it is also the first record of this beaked whale from the Gulf of Mexico.—GORDON GUNTER, *Gulf Coast Research Laboratory, Ocean Springs, Mississippi. Received December 16, 1954.*

NOTES ON THE REPRODUCTION OF A BARINGO GIRAFFE

Koga (Kagaku Oaho, 27, 1938) reported on the birth of a Nigerian giraffe, female, *Giraffa camelopardalis peralta* at the Ueno Zoo at 7:24 PM. Parturition time was reported to be three hours, nineteen minutes. The calf gained its feet at 7:56 PM, 32 minutes after birth, though it did not eat for 42 hours.

On the morning of December 3, 1954, we were afforded the unusual opportunity of observing the birth of a Baringo giraffe, male (*G. c. rothschildi*), at the San Diego Zoo. Parturition was first seen to be in progress about 10:15 AM. The forelegs of the foetus had appeared at this time followed soon after by the ventrally positioned head and neck. During most of the labor period the mother remained on her feet moving restlessly about the enclosure. As uterine contractions occurred she would spread her hind legs and extend her head and neck forward almost paralleling the ground. Occasionally she would lie down for short intervals.

After the forelegs and neck of the foetus were expelled, very little progress was made until about 11:55 AM when the anterior part of the body was extruded. Birth was completed shortly after this at 12:06, approximately two hours after it was first noticed that labor was in progress.

With delivery accomplished, the mother began carefully cleaning her offspring eating the foetal membranes during the process. The placental tissues, expelled later, were not consumed although they were left in the enclosure until the following morning.

Shortly after birth the calf raised its head to an erect position and repeatedly made unsuccessful attempts to gain its feet. The mother did not assist beyond nuzzling and licking although she was quite solicitous and resented any close approaches to her enclosure. It was not until the following morning that she reluctantly permitted us to enter. At this time the calf was transferred to a sleeping compartment which had been provided with a bed of fresh hay. Attempts to assist it to stand so that nursing would be possible failed, and artificial feeding on a diet of Colostrum, obtained from a local dairy, was employed. Death ensued about 1:30 AM, December 6. The autopsy report (Clyde McMorrow, M.D.) indicated death was due to pneumonia. Extensive muscle damage of the left thigh was present. This was attributed to a contraction ring in the cervix of the mother during parturition and, no doubt, accounted for the failure of the calf to gain its feet.

The calf resembled the adult closely except for size and lighter buffy color of the spots. The horns had not formed, but tufts of long black hair marked their future positions on the head. The following weight (kgs.) and measurements (cms.) were taken shortly after death: Total length, 204; tail length, 39; hind foot, 68; ear (crown), 16.5; tip of foreleg to withers, 153; greatest girth, 108; weight, 72.8.

The parents were acquired by the San Diego Zoo October 25, 1938, at which time they were estimated to be two years of age. They have produced seven offspring as follows: 3/15/42—male, 6/5/44—female, 4/13/46—male, 10/12/48—male, 10/3/50—female, 8/24/52—male, 12/3/54—male.

In all cases except the last, parturition occurred during the night and was usually preceded by extreme nervousness on the part of the mother the day before.—GEORGE H. POURNELLE, *Zoological Society of San Diego, California. Received December 14, 1954.*

REVIEWS

Zim, Herbert S. and Donald F. Hoffmeister. MAMMALS. A GUIDE TO FAMILIAR AMERICAN SPECIES. Simon and Schuster, New York. 160 pp.; 218 color portraits; range maps. Price, $1.95.

This new addition to the Golden Nature Guide series should serve to popularize mammals as only a few recent books have. Aimed at the general public, the mammals included are depicted with beauty and accuracy. For naturalness, life-like posture, and background these portraits by James Gordon Irving deserve high praise. That they could be produced in such excellent color rendition so prolifically and inexpensively is a remarkable publishing feat.

Each species portrait is accompanied by a brief commentary that presents some essential facts on size, food, habits, and life history. These facts are necessarily limited by space, but are well chosen and accurate. Small range maps give a good idea of the general distribution of each mammal today and in the past.

An introductory section provides a colored picture key to the main types of mammals. This is followed by some general information and suggestions for seeing and studying mammals in the field. It would have done no harm in this section when writing on economic values and conservation to point out that wild mammals may sometimes give man some trouble. Certainly most people are aware that problems exist and it serves no good purpose to hide the facts.

Suggestions for study include brief comments on observing, photographing, collecting tracks and mammals, preparing skins and skulls, and using museums and zoos. For the general public, the suggestions on wild mammals as pets might well have been worded differently. In most cases such pets suffer an unhappy end.

Phylogenetic "trees" are provided for mammals in general, and for each large order and family. Even the small colored portraits that illustrate these "trees" are models of accuracy and charm. Each of these phylogenetic "trees" is accompanied by a short discussion that should be of great educational value for the layman, since these comments skillfully tie the separate accounts into a meaningful grouping. Scientific names are relegated to a key list in the back of the book. It is doubtful that their parenthetical inclusion in the species accounts would have scared off any readers, and they would have been more instructive there.

Many of the individual portraits are accompanied by backgrounds that are delightful and well-chosen to give the reader an accurate idea of the type of habitat in which the mammal lives.

It is apparent at this point that I have much praise for this little book; and authors, artist, and publisher are congratulated for a splendid accomplishment. It should do much to arouse intelligent, popular interest in our natural heritage of mammals.—W. ROBERT EADIE.

Peterson, Randolph L. NORTH AMERICAN MOOSE. Univ. of Toronto Press. xi + 280 pp.; 35 tables; 66 figs. (line cuts and halftones). 1955. Price, $12.50.

This reviewer's qualifications for writing about a book on North American moose are limited. Nevertheless, having watched tourists equipped with cameras in Yellowstone National Park circle closely and brazenly around two magnificent bulls in the velvet, and having observed the moose in more natural situations feeding in the lakes of Canada's wilderness, I find the book so satisfactory in filling a need for information about these great deer that I am constrained to ignore my limitations.

Dr. Peterson has succeeded in packing into this modest-sized work most of the published information on the North American moose. In addition he has added a great deal of fresh information gathered by himself and co-workers from Canada's ideal moose habitats. Indeed, much pertinent information on the moose from European workers is included by way of comparison and supplement.

After a brief introduction to set the stage by citing the chief contributors of information on the moose from 1674 to 1934, the author proceeds systematically to present his data. I

like especially the early quotation on page three from Josselyn (1674), "The *Moose* or *Elke* is a creature, or rather if you will a Monster of superfluity . . . their horns . . . very big (and brancht out into palms) the tips whereof are sometimes found to be two fathoms asunder . . . and in height from the toe of the forefoot, to the pitch of the shoulder twelve foot, both which hath been taken by some of my *sceptique* Readers to be monstrous lyes."

In brief chapters, the taxonomy, paleontological history, post-glacial dispersal, and early history of the moose in North America are presented. Then follows a vital chapter on the general population status of the moose. In those limited regions of the United States where the moose remains, its status is not entirely discouraging, but it is obvious that the last great refuge for this huge deer will be the wilderness areas of Canada. Detailed data are given on status in Ontario.

The chapter on rate of reproduction reveals the serious lack of information on this vital aspect of moose ecology. Under "General Life History" much vital information is presented on calves; parent relationships; calf mortality and survival; sex ratios; growth, weights, and measurements; pelage; teeth development; body development; antlers, breeding habits; and maturity and old age. One would gather from the account on breeding that an actual eye-witness account of the mating act of the North American moose does not exist.

An interesting chapter on general behavior and activities gives information on such aspects as senses; disposition, temperament and mannerisms; protective behavior; reactions to humans; sociability; swimming and diving; travel, gait, and speed; daily and seasonal activity; and territoriality (no evidence for) and home range.

The section on food and food habits is the most detailed in the book. It is here that the author has made his most important personal contribution, and this section should be very valuable to future workers. The sections on habitats and on relationships with other animals are important in correlation with the food habits studies. The great significance of the possible competition between the moose and the white-tailed deer is rightly emphasized. With the rapid northward increase in numbers of white-tailed deer, game managers may be properly concerned with preserving the remaining strongholds of the moose in suitable condition for continued occupancy in reasonable numbers by the moose.

Predation by associated wild animals is suitably deemphasized and viewed in a rational perspective, but this reviewer would have appreciated a stronger stand on the bounty question. Nevertheless, the author makes clear in one brief paragraph that he sees no accrued benefit to the moose from predator bounties.

Additional chapter headings are, "Diseases, parasites, and insect pests;" "Accidents;" "Population studies;" and "Management." The magnitude of the role that accidents play in reducing moose numbers was surprising to this reader.

There are two appendices by other authors: "Appendix A. A study of mandibular tooth-wear as an index to age of moose" by R. C. Passmore, R. L. Peterson; and A. T. Cringan; and "Appendix B. Studies of moose antler development in relation to age" by A. T. Cringan.

The book is well illustrated, and many moose activities are portrayed by excellent photographs. Numerous tables and charts provide supporting data. It is unfortunate that the book could not have been produced more economically, thus giving it a wider sale. Despite this, few serious students of mammals can afford not to have this comprehensive reference work on the moose on their shelf.—W. ROBERT EADIE.

[This second review of NORTH AMERICAN MOOSE arrived after the above review had been set in galley. Since it presents viewpoints from a more qualified critic it is published also.—Ed.]

There have been few good books devoted to single species of North American big game. O. J. Murie gave us a good one on elk, and Roe produced one on bison with more historical skill than biological competence. Einarson wrote an excellent volume on the pronghorn antelope. Skuncke gave us an apparently excellent moose book in Swedish in 1949, but North Americans are peculiarly clumsy with languages. To most of us this book has remained a well-bound and beautifully illustrated volume of mystery. Inklings of its content have

come only from brief translations done for a few moose enthusiasts. Now Peterson has written a North American moose book.

The plan of this new book is similar to Murie's on elk. It is an intense volume. Fact follows fact throughout in a manner that reduces reading ease but increases value for reference. The contents are as follows by major headings, which are not necessarily chapter headings: taxonomy, history, population trends by provinces and states, reproductive rate, life history, behaviour, food habits, habitat, relationships with other animals, diseases and parasites, population studies, management, and two appendices, one on tooth wear relative to age, the other on antler development relative to age.

The price is unfortunate. Prices of technical books generally have risen sharply in recent years, and in many cases have left the ability of the scientist and technician to buy far behind. Since this book has only about 290 pages, the cost per printed page is over four cents. Both the binding and illustrations are good but by no means luxurious. These cannot be considered as major contributors to production cost. It must be concluded that the high price is an extreme example of high printing costs generally, accentuated in this case by prediction of limited sales. We have become so used to the benefits of mass production that the cost of limited production may appear unreasonable.

In a review such as this it is traditional to point out errors and omissions. Someone has said that this is often followed by an account of how the reviewer would have written a better book. In this case there can be no doubt that the author stands alone in his knowledge of his subject. Nevertheless there are critical comments to be made. A review has little value if it is all praise and summary.

There are only two places where Peterson the writer shows through the nearly mechanical recording of facts. In an early chapter he postulates a stimulating theory of glaciation determining the present distribution and subspeciation of moose in North America. It is an excellent piece of work, combining taxonomy and pleistocene geology to form an acceptable explanation for racial differences of moose in America. The author terminates his book with a discussion of management. Here again there is relief in being nearly free from references to the works of others.

Considerable data on reproductive rate shows that in moose it is unexpectedly low. Calfless cows constitute 60 to 70 per cent of all cows in data collected from Newfoundland to Alaska. There is room for large errors in these figures, however, as the author points out. Cows do not normally produce young until near their third birthday. There are thus two age classes in the female population that are not productive. Since there is no easy way to separate yearlings from adults, and in British Columbia observers trained by seeing up to a hundred moose daily have failed to recognize calves as such in winter, these young age classes could account for many of the calfless moose cows observed. In addition, moose habits and habitat are such that many a "calfless" cow has a full udder. Finally, calf counts made in middle and late summer are liable to bias if used to illustrate reproductive rate because of the high natural mortality rate that besets most animals in early life. For these many reasons, figures showing a high percentage of barren cows must be treated with caution.

As to sex ratios, they are equal in Eastern Canada, but in British Columbia and Alaska cows tend to outnumber bulls about two to one. Peterson fails to point out that this difference between east and west may not be real, but due to inaccurate data from the west as a result of mountainous terrain. Bulls tend to stay at higher elevations while observers and hunters often find lower elevations the most productive areas in which to work. Accurate sex ratio determination in the mountains requires special care before results can be used with complete confidence.

After analysing much information on the age compositions of populations across America, Peterson concludes that the annual recruitment to the adult herd rarely exceeds 20 per cent. The average is about 16 per cent. This is a high percentage to result from herds in which about half the cows are said to be productive, and is probably a reflection, in part, of light predation on moose throughout most of its range.

It is stated that "moose show no well marked migrations as do wapiti and caribou." Certainly the caribou is unique in this respect, but in British Columbia there are moose migrations as "well marked" as any undertaken by elk anywhere. There is the difference, however, that elk movements are more conspicuous because of herding habit and the open ranges that they usually frequent.

The distinction between "voluntary" and "enforced" yarding of moose in winter is not clear to this reviewer. The difference seems arbitrary, or am I out of step in believing that a "yard" is merely an area of range that receives concentrated use in winter, presumably because that area offers certain advantages, whether from insolation, topography, cover, food or other reasons.

The chapter on habitat gives some excellent word pictures of what is superior moose range in Ontario. This, and the chapters on food, are based upon a previous publication (Peterson, Studies of the food habits and the habitat of moose in Ontario. Contrib. Roy. Ont. Mus. Zool. Palae. No. 36, 1953). Balsam fir (*Abies balsamea*) appears to be the most important food in the East, largely a result of its abundance. There are, however, thirteen species of plants that have lower density there, but are subjected to heavier use. The most thoroughly used of these are willows, which are not usually abundant on eastern moose ranges. Perhaps the greater abundance of willow on moose ranges in the mountainous west partly explains the more dense populations there. On some extensive ranges in British Columbia willow bushes on dry sites average only six feet apart, a condition which would be quite unusual in Ontario.

Peterson used the Aldous Method to evaluate his ranges, partly because it had been used on Isle Royale and comparable data were desirable. This survey method has been much used in the big game ranges of America. Its essential element is an estimate of the percentage of summer's growth used in the following winter. The method has some pitfalls. Perhaps the most serious is that those who analyse the data often lose sight of the meaning of "per cent." Thus 50 per cent use of a balsam fir is considered equal use to 50 per cent use of a willow, which is true in the sense that in eating half a sausage and eating half a pig, each is half eaten. Similar proportions need not be similar quantities. Peterson does not appear to have improved on previous surveys using this method.

This new book on North American moose covers so much ground with an obvious objective to keep down costs through economy of words, that all of it will not satisfy everyone. Most will agree, however, that here is an outstanding reference work on a spectacular and valuable species of big game. This will be our standard moose book for many years. It should be in the library of everyone interested in ungulate big game.—R. Y. Edwards, *Parks and Recreation Div., B. C. Forest Service, Victoria, B. C.*

BRIEFLY NOTED

Turner, C. Donnell. General Endocrinology. Ed. 2. W. B. Saunders Company, Philadelphia. xi + 553 pp.; 171 figs. 1955. Price, $8.00.

The second edition of this solid work on endocrinology contains a new section, "Adaptive Reactions to Stress," that should be of value to many students of wild mammals. An elucidation of the General Adaptation Syndrome is given here with references to the original sources. This whole concept may have great significance to students of animal fluctuations, as has been pointed out in recent years. Here is a convenient, lucid review of the concept and some of its implications.

Ashbrook, Frank G. Furs, Glamorous and Practical. D. Van Nostrand Co., Inc., New York. xiv + 88 pp.; photos. 1954. Price, $2.95.

This informative book takes the reader through the mysteries of the fur trade and fur manufacturing processes. Statistical data on the world fur trade are given that emphasize the importance of the United States as a producer, importer, and consumer of raw furs.

The details of the processing of various kinds of pelts will be interesting and revealing to many. Numerous photographs illustrate many of the actual operations that take place.

Facts on individual fur types are presented. The emphasis given Chinchillas is somewhat

misleading in view of the current status of this phase of the fur industry, where breeders are sold for fantastic prices and few pelts ever reach the market.

A consumer's guide to furs in the form of an extensive table is a very useful part of the book. Certainly all students of mammals should be familiar with the facts presented in this book as representing one utilitarian aspect of the science of Mammalogy.

Chandler, Asa C. INTRODUCTION TO PARASITOLOGY. Ed. 9. John Wiley & Sons, New York. 799 pp.; 257 figs. 1955. Price $8.50.

The ninth edition of this standard textbook on Parasitology has been extensively revised and brought up to date. Approximately half the figures have been redone.

While the emphasis is still on the parasites of man there is much information on those of other animals. Fully revised are the sections on resistance and immunity, leptospirosis, amebas, hemoflagellates, schistosomes, insecticides and repellents, and trypanosomiasis. The sections on malaria, syphilis, and Toxoplasma have been brought up to date. There is new information on onchocerciasis, filariae, and many more.

It is hoped that this new edition will serve to stimulate additional interest in the parasites and vectors of diseases in wildlife.

Colbert, Edwin H. EVOLUTION OF THE VERTEBRATES. John Wiley and Sons, New York. xiii + 479 pp.; 122 figs. 1955. Price (trade ed.), $8.95.

This new textbook of vertebrate paleontology is written for the introductory level or for the general reader. In smoothly written text the author sketches in bold outline the story of vertebrate evolution as seen from the fossil record. The numerous figures illustrate group relationships, skeletal structures, adaptive radiations, etc. Chapter headings are illustrated with black and white sketches of fossil restorations in probable habitat scenes. Others are scattered among the numbered figures. These enliven the text and give the casual reader and introductory student something to visualize other than dry bones.

The book contains a classification of the chordates, an annotated list of references, and a generic index in addition to a subject index.

"Evolution of the Vertebrates" is certain to find a place in the education of young zoologists.

RECENT LITERATURE

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[Reprints of this section may be purchased from the Corresponding Secretary]

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COMMENTS AND NEWS

SUPPLEMENT TO CHECKLIST

At the 35th Annual Meeting the Board of Directors approved a program for the publication in the Journal of Mammalogy of supplements to the Miller and Kellogg "List of North American Recent Mammals." To insure adequate coverage, authors of papers of taxonomic or geographic import are urged to send reprints (or otherwise call attention to their work) to the subcommittee chairman, Richard G. Van Gelder, Museum of Natural History, University of Kansas, Lawrence, Kansas.

HIGGINS LAKE, MICHIGAN, FOR 1956

The Thirty-sixth Annual Meeting of the American Society of Mammalogists will be held at Higgins Lake, Michigan, June 16–20, 1956. Many will remember the pleasant and successful meeting held there in 1947. The meeting will be followed by that of The American Society of Ichthyologists and Herpetologists, beginning on the 20th.

FISHER ABUNDANCE

A. Brazier Howell calls attention to increased numbers of fishers (*Martes pennanti*) in Maine as reported by Chief Warden Elmer Ingraham. He states, "With the exception of one month in 1950, Maine has had a closed season on fishers for about 30 years. Word is now received that they have spread from the mountainous sections into the lowlands of most of the state, and that an open season has been declared for the next two years. Until at least next year, no estimate of their numbers is possible, but indications point to an unusually large population."

In view of the recent assessment of the large population of fishers in New York State (Hamilton and Cook, N. Y. Fish and Game Jour., 2: 13–35, 1955) it is interesting to note the parallel situation in Maine, and to wonder about the status of fisher populations in other northeastern states having suitable habitat.

CORRECTIONS

Mr. J. R. Ellerman has called my attention to a factual error in my paper on rodent classification ("A Revised Classification of the Rodents") in the May issue of the JOURNAL OF MAMMALOGY. He points out that the genera *Cardiocranius* and *Salpingotus*, both referable to the Dipodidae, do not have fused metatarsals nor a cannon bone, so that such fusion cannot be a family characteristic of living dipodids.

I also caught three errata in the printed version of the paper.

They are: p. 166, line 30—Theri*do*myidae; line 33—classification; p. 180, 8 lines from bottom—OCTODON*TIDAE*.—A. E. Wood, *Biology Department, Amherst College, Amherst, Massachusetts.*

In the August issue, Jour. Mamm., 36(3): 473 and 474, read *hemionus* for *hemionius* wherever it occurs.—Ed.

DEATHS

Recently reported deaths of members of the Society are as follows (*Charter Member): ***Charles F. Batchelder, Henry B. Chase, Jr., Edward F. Chatelain, Edna M. Fisher, Paul B. Johnson, J. E. Keays, James H. MacGregor, and Elizabeth R. Vandegrift.**

DATE OF ISSUE OF PREVIOUS NUMBER

Journal of Mammalogy, Vol. 36, No. 3 was mailed August 30, 1955

THIRTY-FIFTH ANNUAL MEETING

THIRTY-FIFTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF MAMMALOGISTS

June 12–16, 1955

The thirty-fifth annual meeting of the American Society of Mammalogists was held at the University of Southern California, Los Angeles, California, June 12–16, 1955. Sessions were held in Hancock Auditorium.

The local committee on arrangements consisted of: William V. Mayer, *Chairman*, Robert M. Chew, Henry E. Childs, George H. Pournelle, Edward T. Roche, and Kenneth E. Stager.

PROGRAM

Sunday, June 12

8:00 PM

Directors' Meeting, Town and Gown Residence Hall

Monday, June 13

8:30 AM

Registration, Foyer, Hancock Auditorium

9:30 AM

Welcome. Earl C. Bolton, *Administrative Assistant to the President, University of Southern California.*

Response. William H. Burt, *President, American Society of Mammalogists.*

1. Some Problems of Applied Small Mammal Sampling in Western North America. Keith Murray, *California Department of Public Health, Fresno, California.*

2. Recent Methods and Results of Census of the California Gray Whale. Raymond M. Gilmore, *U. S. Fish and Wildlife Service, La Jolla, California.*
3. Sex Ratios of the Bat *Pipistrellus subflavus*. Wayne H. Davis, *University of Illinois, Urbana.*
4. Comparative Population Dynamics in Two Species of *Microtus*. Robert S. Hoffman, *Museum of Vertebrate Zoology, Berkeley, California.*
5. Dynamics of a Pocket Gopher Population. Walter E. Howard, *University of California, Davis*, and Henry E. Childs, Jr., *Compton College, Compton, California.*

12:00 NOON

Annual Group Photograph, Front Entrance, Hancock Foundation

2:00 PM

The Society co-sponsored this session with the Pacific Section, Society of Systematic Zoology

6. Observations on a Xeric Race of *Bassariscus astutus*, from the Deserts of Southeastern California. Kenneth E. Stager, *Los Angeles County Museum, Los Angeles, California.*
7. Further Remarks on Studies of the Eastern *Phenacomys*. Randolph L. Peterson and J. B. Foster, *Royal Ontario Museum of Zoology and Palaeontology, Toronto.*
8. A Population of the Striped Field Mouse, *Apodemus agrarius mantchuricus*, in Central Korea. Philip M. Youngman, *University of Connecticut, Storrs.* (This paper was awarded an honorarium.)
9. Distribution and Variation of the Montane Meadow Mouse, *Microtus montanus*. Sydney Anderson, *University of Kansas, Lawrence.*
10. Defense of the Subspecies. Stephen D. Durrant, *University of Utah, Salt Lake City.*
11. A Definition of the Order Pinnipedia. Robert B. Chiasson, *Stanford University, Stanford, California.*
12. Evidence for the Validity of the Rodent Sub-order Hystricomorpha. Stuart O. Landry, *University of Missouri, Columbia.*
13. The Status of Dipodomys nitratoides exilis. Seth B. Benson, *Museum of Vertebrate Zoology, Berkeley, California.*

7:30 PM

Get-together and Smoker
Graduate Lounge, Basement, Town and Gown Residence Hall
Entertainment: Film, Walt Disney's "Living Desert"

TUESDAY, JUNE 14

9:00 AM

14. Response of White Mice to Chronic and Acute Water Deprivation. Robert M. Chew and Ralph Hinegardner, *University of Southern California, Los Angeles.*
15. Some Notes on Water Consumption in *Peromyscus maniculatus osgoodi*. Olwen Williams, *University of Colorado, Boulder.*
16. A Morphologist's Plea for Conservation. Kenneth L. Duke, *Duke University School of Medicine, Durham, North Carolina.*
17. Morphology and Physiology of the Caecum in Lagomorphs and Rodents. Wilhelm Harder, *Institut für Fischereibiologie der Universität Hamburg, Germany.*
18. Preliminary Comparisons of the Adrenals in Some Insectivorous Mammals. Robert L. Rudd, *University of California, Davis.*

10:30 AM

Annual Business Meeting, Election of Officers

2:30 PM

19. Changes in Splenic Weight Associated with Hibernation in Bats. William Z. Lidicker, Jr., and Wayne H. Davis, *University of Illinois, Urbana.*
20. Differential Body Temperatures in the Arctic Ground Squirrel Awakening from Hibernation. William V. Mayer, *University of Southern California, Los Angeles.*
21. New Records of Mammals for Guerrero. William B. Davis, *Texas A. and M. College, College Station, Texas.*
22. The Tamaulipas-Rio Grande do Sul Transect of the Neotropical Region. Philip Hershkovitz, *Chicago Natural History Museum.*
23. Mammals of the Thousand Islands Region, New York. William E. Werner, Jr., *Blackburn College, Carlinville, Illinois.*
24. The Natural History of Pikas, with Special Emphasis on *Ochotona princeps*. J. Harold Severaid, *Sacramento State College, Sacramento, California.*
25. Film: Natural History of *Ochotona princeps muiri*. J. Harold Severaid, *Sacramento State College, Sacramento, California.*

6:30 PM

Annual Dinner, Carl's Restaurant, 3760 S. Figueroa Street

WEDNESDAY, JUNE 15

9:00 AM

26. The Travel of the Merriam Chipmunk. Enid A. Larson, *Hastings Reservation of Natural History, Carmel Valley, California.*
27. Molt in the Pocket Gopher (*Thomomys bottae*). G. Victor Morejohn and Walter E. Howard, *University of California, Davis.*
28. Notes on the Biology of the Collared Lemming (*Dicrostonyx*) in Captivity. W. B. Quay, *University of Michigan, Ann Arbor.*
29. Relation of Coloration of Mammals to Low Temperature. Arthur Svihla, *University of Washington, Seattle.*
30. Winter Pelage in *Lepus americanus* along the Pacific Coast. Robert T. Orr, *California Academy of Sciences, San Francisco.*
31. Reproduction of the Opossum in New York. W. J. Hamilton, Jr., *Cornell University, Ithaca, New York.*

10:30 AM

Final Business Meeting

2:00 PM

32. The Utilization of Aspen at a Beaver Colony in the Sierra Nevada. Joseph G. Hall, *Museum of Vertebrate Zoology, Berkeley, California.*
33. Observations on the Bioclimate of Some Taiga Mammals. William O. Pruitt, Jr., *Arctic Aeromedical Laboratory, Fairbanks, Alaska.*
34. Food Habits of the Hog-nosed Skunk in Texas. Walter P. Taylor, *Claremont Graduate School, Claremont, California.*
35. Territorialism in Certain Deer and its Possible Significance. William Graf, *San Jose State College, San Jose, California.*
36. Observations on the Ecology and Comparative Behavior of Two Desert *Peromyscus*. Norman B. McCulloch, *Los Angeles, California.*
37. Introduced Mammals and their Influence on Native Biota. Antoon de Vos, *Ontario Agricultural College, Guelph*, Richard H. Manville, *Michigan State University, East Lansing*, and Richard G. Van Gelder, *University of Kansas, Lawrence.*
38. A Young Northern Elephant Seal Visits Monterey County, California. Jack C. von Bloeker, Jr., *Los Angeles City College, Los Angeles, California.*
39. Temperature Regulation in the Wallaby, *Setonix brachyurus*. George A. Bartholomew, *University of California, Los Angeles.*

7:30 PM

Film Preview, "The African Lion," Walt Disney Studios, 2400 West Alameda Avenue, Burbank, California

THURSDAY, JUNE 16

8:00 AM

San Diego Zoo Field Trip

12:00 NOON

California Desert Field Trip

DIRECTORS' MEETING

The meeting of the Board of Directors was called to order by President William H. Burt. Reports of the Treasurer, Auditing Committee, Trustees, and Editorial Committee were read and accepted.

The following budget was authorized for 1955:

Journal of Mammalogy and Editor	$9,800.00
Expenses of the Treasurer	450.00
Expenses of the Corresponding Secretary	450.00
Expenses of the Membership Committee	50.00
Contingent Fund	250.00
Zoological Record Fund	100.00
Index Committee	10.00
Honoraria for Young Mammalogists	200.00
Total	$11,310.00

There was considerable discussion of the question of the Society's reaffiliation with the American Institute of Biological Sciences. No action was taken, however. After a discussion of the increasing cost of printing the Journal of Mammalogy, it was decided that the President should appoint a committee to investigate the desirability of having the Journal printed by a different publisher.

Following a report by President Burt that C. C. Sanborn would not be able, because of ill health, to carry on in the capacity of Trustee, D. D. Davis was elected as Trustee for the 1956–58 term. W. Robert Eadie was reappointed as Chairman of the Editorial Committee.

The President presented a suggestion by R. G. Van Gelder that a committee be appointed to prepare current supplements to the recent new edition of the "List of Land Mammals of North America," to be published in the Journal of Mammalogy. The Directors approved this suggestion and proposed that Mr. Van Gelder be appointed to one of the existing committees to carry out this plan.

ANNUAL BUSINESS MEETING

The first session of the annual business meeting was called to order with 80 members present. Reports of the Corresponding Secretary, Treasurer, Auditing Committee, and Trustees were presented. The following officers were elected: William B. Davis, President; Robert T. Orr, Stephen D. Durrant, Vice-Presidents; Randolph L. Peterson, Recording Secretary; Caroline A. Heppenstall, Treasurer; George C. Rinker, Corresponding Secretary. J. K. Doutt, William V. Mayer, Emmet T. Hooper, Oliver P. Pearson, and Viola S. Schantz were elected as Directors for the 1955–57 term; Kenneth L. Duke was elected Director to fill the unexpired term (1954–56) of Stephen D. Durrant.

The Society learned with regret of the deaths of eight members, one a charter member (*): *Charles F. Batchelder, Henry B. Chase, Jr., Edward F. Chatelain, Edna M. Fisher, Paul B. Johnson, J. E. Keays, James H. MacGregor, and Elizabeth R. Vandegrift.

At the end of the year 1954, there was a small increase in the total mailing list of the

Society. Although there were more members dropped for delinquency in dues, more subscriptions cancelled, and more deaths reported than in 1953, these were more than offset by fewer resignations and by reinstatement of members who had been suspended. Nominees for membership totalled 116; resignations, 26; members dropped for delinquency, 65; deaths reported, 8. There were 55 new subscriptions but 72 cancellations.

The Corresponding Secretary presented this summary of memberships and subsciptions for 1953 and 1954:

	1953		1954	
MEMBERSHIP				
Changes since last annual report				
Nominees		116		116
Resignations	42		26	
Deaths reported	5		8	
Members dropped (delinquent)	53		65	
Total	100	116	99	116
Net change		+16		+17
Status as of December 31, 1954				
Honorary members		7		9
Life members		65		71
Annual members		1351		1360
Total membership		1423		1440
SUBSCRIPTIONS				
Changes since last annual report				
New subscriptions		55		55
Subscriptions cancelled	58		72	
Net change		−3		−17
Total paid subscriptions		444		427
MAILING LIST				
Total membership		1423		1440
Members not receiving Journal		166		160
Total members receiving Journal		1257		1280
Total paid subscriptions		444		427
Total mailing list		1701		1707
Net change		−4		+6

There was a very welcome decrease in the number of members delinquent in payment of dues. Members are urged to see that this trend continues because of the burden of expense and time which delinquents place on the Society and the officers.

The final session of the business meeting was called to order June 15, with 73 members present. The reports of the following committees were read and accepted: Conservation of Land Mammals (A. Starker Leopold); Marine Mammals (Robert T. Orr); Editorial (read by George C. Rinker); Index (Viola S. Schantz); Honoraria for Young Mammalogists (read by George C. Rinker).

The recommendation of the Board of Directors that H. E. Anthony be accorded the status of Honorary Member was presented to the members, who voted unanimously in favor of it.

The Resolutions Committee presented three resolutions which were passed: (I) *Whereas* the wild European rabbit (*Oryctolagus cuniculus*) has proven detrimental to the economic and aesthetic interests of man where introduced, and

Whereas individuals and clubs in some States have seen fit to import for sport this species from San Juan Islands, Washington, and other islands, and the presence of this species on the North American mainland cannot be economically or aesthetically successful,

Therefore be it resolved that the American Society of Mammalogists at its 35th annual meeting in Los Angeles, California, urges the Washington State Game Department and the State Legislature of Washington, respectively, to prevent the removal of *Oryctolagus cuniculus* from the San Juan Islands to the mainland of North America.

Be it further resolved that the Pennsylvania Game Commission, the New York Game Commission, and the Ohio Game and Fish Commission, be urged to make all possible attempts to eradicate the European rabbit wherever it has been introduced and still persists.

(II) *Whereas* the Wichita Mountains area of Oklahoma is a unique biotic and geological area, and

Whereas part of this area has been dedicated to the perpetuation of endangered species of North American big game, particularly the American Bison, by individuals who purchased the land and deeded it to the Federal Government in trust forever for this express purpose, and

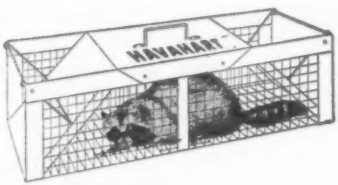
Whereas its scenery, lakes, and other features provide a recreational area in a region where other recreational facilities are not available,

Therefore be it resolvéd that the American Society of Mammalogists at its 35th annual meeting at Los Angeles, deplores the attempt of the Department of Defense to obtain transfer of a part of this refuge for the purpose of enlarging the Fort Sill Artillery Training Center and that the Department of the Interior be urged to refuse the granting of this transfer of title.

(III) *Resolved* that the American Society of Mammalogists in session at its 35th annual meeting at Los Angeles on June 15, 1955, tenders its sincere thanks and appreciation to the President of the University of Southern California, to his administrative assistant, Dr. Earl C. Bolton, and to the members of the local committee on arrangements under the Chairmanship of William V. Mayer, for their generous hospitality and untiring efforts which contributed to the success of the 35th annual meeting and to the enjoyment of all members, their families and friends who attended.

President Burt presented Charleston, South Carolina, Denver, Colorado, and Higgins Lake, Michigan, as possible places for the 1956 annual meeting. The voting was in favor of Higgins Lake, Michigan. An informal poll indicated a preference for June as the time for the meeting.

HAVAHART HUMANE ANIMAL TRAPS



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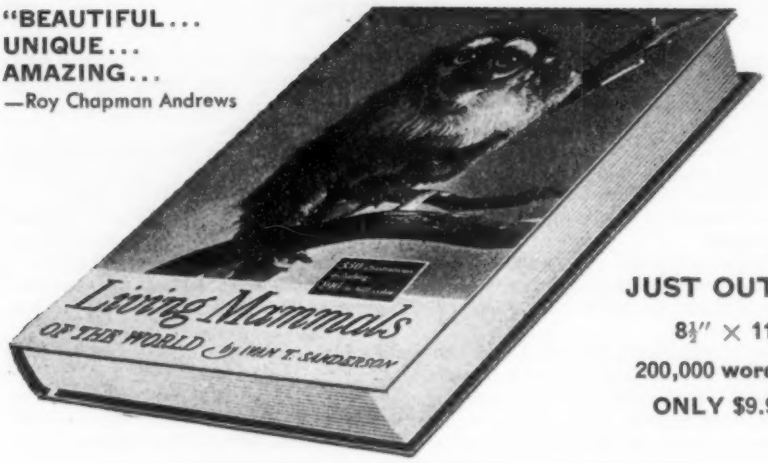

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